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The Illustrated London News

The signal squad leaving the trenches to follow up an advancing force with a telephone line

DIRECTING AN ATTACK—[See page 166]

What Is a Disease*—II

By Charles Mercier, M.D., F.R.C.P., F.R.C.S.

An Attempt to Formulate Definitions of the Fundamental Concepts of Medicine

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THE next question to determine is whether structural damage is necessary to the concept of disease. Do we, when we think of a disease, necessarily mean structural damage with its consequences, or may there be diseases in which no structural damage is known? Unquestionably there may. In many of the diseases, nay, in most of the diseases, considered as such by our forefathers, no structural damage formed part of the concept, or was know to exist. When cough, syncope, hæmoptysis, hæmatemesis, hæmaturia, albuminuria, were reckoned as diseases, they had no structural basis. In our own time, paralysis agitans and diabetes were known as diseases, though they had no known structural basis. It is true that in these cases, though no structural basis was known, yet it was assumed that there was a structural basis, and it was confidently anticipated that this structural basis would eventually be found; so that it may be contended that some structural basis, even if only conjectural or postulated, entered into our concept of these diseases; but this is not so, for there are some diseases, to which every one would allow the title, in which no basis of structural damage is suspected, and in which we feel confident that no such basis exists. In hysteria, for instance, in blindness and deafness from shock, in some cases of epilepsy, in some cases of insanity, we can affirm with confidence that no structural basis underlies the disease; and yet these are undoubtedly and indisputably diseases.

Although, therefore, in many cases the structural basis of the symptoms does enter into our concept of the disease, yet in others a structural basis forms no part of the concept; and in these cases nothing is left but symptoms. The symptom or symptoms then constitute the disease, and we are once more confronted with the problem of what it is in our way of contemplating a symptom or a group of symptoms that converts it or them into a disease. Is it the combination of two or more symptoms? No, for in the whilom diseases cough, hæmaturia, palsy, dropsy, and in the present-day diseases writer's cramp, wryneck, neuralgia, Dupuytren's contraction, and others, there is but a single symptom; and moreover there are combinations of symptoms that do not constitute a disease. A patient may suffer simultaneously from the symptoms of heart-disease, ringworm, and hammer-toe, but we do not regard this combination of symptoms as a disease: we regard them as three different diseases. This instance throws some light upon our problem. It is clear from it that whatever symptoms a patient may present, they do not constitute a disease unless they are correlated together; that is to say, unless they are combined by a casual nexus into a single group. It may be that we can identify the tie that binds them together, as when we find symptoms so diverse as disorder of the circulation, asthenia, vomiting, and pigmentation of certain areas of the skin, all associated with and dependent on destructive disease of the supra-renals; or it may be that no such tie can be discovered, but yet the occurrence in different persons of the same distinctive group of symptoms, or their repetition from time to time in the same person, as in epilepsy, satisfies us that there must be a causal tie; but in either case, we take the whole of the correlated symptoms, and mentally combine them with the casual tie, and call the whole correlate THE DISEASE. The correlating tie which binds the group together in our minds may be structural damage of this organ or that, or it may be a microbic invasion, or it may be a poison, or it may be unknown, and purely conjectural; but some tie, some common intra-corporeal cause, must exist or be supposed to exist before we can group the several instances of disease together into an integrated whole or individual thing, and call that object of contemplation a disease. By a disease we mean, therefore, the whole group of correlated disorders, both functional and structural, from which the patient suffers; and by correlated disorders are meant all the disorders that are attributed to a single intra-corporeal cause, together with this cause.

It is necessary to add the qualification "intra-corporeal," for many diseases have a plurality of causes if we take into our consideration extra-corporeal causes. Many diseases need for their causation some special action from without, such as the bite of an infected insect, faulty diet, cold, damp, or what not; but these are not parts of the disease. They do not enter into our concept of the disease. They are causes of the disease, but, being extra-corporeal, they are not parts of the disease.

1. This concept of a disease needs some further qualification before it can be accepted as complete and final. To recur to the combination of rheumatism, heart disease, embolism; these, as long as they co-exist, constitute, with their symptoms and other consequences, a single disease. They constitute a correlated group of disorders, structural and functional, all assignable to a single intra-corporeal cause, the rheumatic infection which correlates them and combines them into a single group, contemplatible as an individual whole. Nevertheless, each of them has a certain separateness and individuality of its own. The rheumatic infection may die out and disappear, and then the disease is no longer rheumatism: it is now heart disease complicated with embolism. Let us suppose that the heart disease also recovers and its structural integrity is restored: the disease is now embolism only. Or there may have been no embolism, and on the disappearance of the rheumatism the disease is heart disease only. Heart disease and embolism may, therefore, in some cases be sole diseases, complete disease, separate diseases; but when they co-exist with each other, or with acute rheumatism, what is their position? Separate diseases they certainly are not, but may not each be regarded as a disease, complete in itself? In a sense, yes: in a sense, no. Each is a complete disease in the sense that it is a group of disorders correlated by a causal structural change sufficient to account for them all; but it is clear that when associated together, or with rheumatism, there is a further correlation, and thus our concept of the disease from which the patient suffers is not complete until they are all correlated into a single more comprehensive concept. The whole disease from which the patient suffers is rheumatism, complicated with heart disease and embolism; but these constitute subordinate correlations, which we may appropriately term *sub-diseases*. Such sub-diseases are not infrequent, and may be of such importance and danger to life as to compel us to concentrate our attention upon them, and to treat them, to the subordination, for the time being, of the principal disease. Optic neuritis is the basis of a sub-disease of tumor of the brain; cirrhosis of the liver is the basis of a sub-disease of alcoholism; nephritis is the basis of a sub-disease of scarlet fever, and so on. The principal disease may subside, or its basis may be removed, and then it disappears, leaving outstanding the sub-disease, which then becomes the principal disease.

2. A disease, then, is the whole group of correlated disorders from which the patient suffers. If there is more than one such correlated group, the patient suffers from more than one disease; but how if there is but one symptom, and this not correlated with any assignable intra-corporeal cause? What is the nosological position of neurlgia, of asthma, of writer's cramp, of diabetes insipidus, of dry mouth, wryneck, and many other such disorders? We call these diseases, but are they rightly so called? Each of them is but a single symptom, uncorrelated with any orther disorder, and due to no assignable cause. Are we justified in calling them diseases? We usually do call them diseases, but we do so with a certain reservation and a shade of doubt. Each of them satisfies the definition in as far as it is in the whole disorder from which the patient suffers; but is it a correlated group of disorders? for that is the definition of a disease. I think it is. I think that when we regard any of these disorders as a symptom, we limit our contemplation of it to what we observe; and we observe but one thing—one uncorrelated disorder; but when we regard the disorder as a disease we do not so limit our contemplation.

3. In the first place, we should not regard as a disease a single twinge of neuralgia, a single attack of asthma, a single rigor, a single manifestation of writer's cramp, or epilepsy. Each single attack or manifestation is a symptom only, or, if more than a symptom, is certainly less than a disease. The disease does not exist until the manifestation is repeated, for not until there are two things to bring into relation with each other can there be a correlation; and it is the correlation, or the group of correlatives, that constitutes the disease. In the second place, when the manifestation is repeated, we do not regard the repetition as fortuitous and accidental. We cannot help supposing that the two or more manifestations are connected together by some underlying cause or condition which persisted in the interval between them. We may not know, and may not be able to conjecture, the nature of this underlying cause or condition, but it is impossible to help postulating its existence; and with this causal basis the manifestations are correlated: by it they are unified and constituted into a single thing—a disease. In the third place, if this basis is postulated to account for repetitions of a symptom, separated from one another by intervals, equally is it postulated when there are no intervals, and the manifstation or symptom is continuously present; or when, as in the case of a fatal first attack of angina pectoris, it cannot be repeated. Whenever we speak or think of a disease, we correlate what we observe with an intracorporeal cause, known, conjectured, or postulated; and it is this correlated group that constitutes the disease.

For consider. Some disorders of function, both extrinsic and intrinsic, are their own symptoms. We witness the disorder, or the immediate result of the disorder. Vomiting, coughing, excessive or defective sweating are extrinsic disorders of this kind: rashes on the skin and caries of the teeth are results of disorder of intrinsic function. Are these disorders diseases, or are they symptoms merely? That depends entirely on whether they do or do not enter as correlatives into a combination of disorders all owning but one intracorporeal cause. Hæmatemesis and coughing are now known to be correlated with other disorders—with disorder of the intrinsic function of the stomach and structural lesion of the stomach in the one case, and with some disorder of the air-passages or lungs in the other. Hæmatemesis and coughing are therefore now reduced in rank, from diseases to symptoms. When they were diseases, they were correlated with a postulated but unassignable cause, and were not contemplated apart from that cause. Now that the cause is assignable, they can be disentangled from it and contemplated apart from it and isolated from it; and so contemplated in isolation they are no longer diseases: they are symptoms. If a rash on the skin cannot be correlated with any other disorder, but only with a cause, known or unknown, it is a disease, and is called the disease of psoriasis, or acne, or icthyosis, but if it can be correlated with other disorders, such as fever, then the rash is a symptom only, and the disease is the group, consisting of the rash and the fever, correlated by some underlying cause. Even the same rash, *e. g.* psoriasis, which, when uncorrelated with other disorders is called a disease, becomes, when correlated with disorders, such as those of gout, a symptom. Caries of the teeth, seeing that it cannot be correlated with any other disorder, is clearly a disease. It is the whole of the disorder that can be attributed to a single intracorporeal cause.

Another difficulty in applying the definition may be felt when the correlating cause of the disorder is widespread, but concentrates its attack mainly upon a single organ. Few diseases are more distinctively diseases, or are better entitled to be called a disease, than Addison's disease; yet in Addison's disease the correlating cause is usually tuberculous disease of the supra-renals, a local manifestation of a tuberculosis which may exist in other parts of the body also. In this case, the sum of the correlated disorders includes more disorders than are included in the concept of Addison's disease; and Addison's disease stands in the same rleation to tuberculosis as endocarditis to acute rheumatism. It is a sub-disease of tuberculosis. It is a local focus, carrying its own symptoms and consequences, of a general infection. Gumma of the brain or of the liver stands in the same relation to syphilis. All these are sub-diseases; but there are practical reasons which render it expedient to put them in a different position. Addison's disease is still Addison's disease, whether the destruction of the supra-renals is due to tuberculosis or to cancer. Tumor of the brain or of the liver has its own characteristic symptoms, which with the tumor make up the disease, whether the tumor is syphilitic, or tubercular, or gliomatous, or cancerous. It is therefore pratically convenient to place the chronic infections, such as tuberculosis, syphlis, cancer, hydatids, and so forth, in a separate class, and to regard each of them as capable of producing various diseases according as their attack is focussed in this organ or in that, reserving the name of "a disease" for those clinical aggregates that result from the localization of an infection in a particular organ.

The presence of certain other correlatives besides

*Science Progress.

disorders of function is sometimes allowed to enter into the concept of a disease. Instances of such correlatives are the time of life at which the disorder occurs, and the extra-corporeal cause to which it is due. By taking into the correlate the time of life at which the disorders occur we construct such diseases as ophthalmia neonatorum, infantile diarrhœa, scurvy of childhood, adolescent insanity, climacteric insanity, senile gangrene, and so forth; and by including in the corrrelate the extracorporeal cause we construct such diseases as caisson-disease, wool-sorter's disease, chimney sweeper's cancer, mountain-sickness, and many others. Are these true diseases, or are they not?

As long as we adhere to the meaning of "a disease"—that it is the whole group of correlated disorders from which the patient suffers, together with their intracorporeal cause—it clearly does not matter in the least what name we give to this group so long as the name is not misleading; but the titles of diseases, when they are meant to be significant of the cause, are so apt to mislead, or to become obsolete and inappropriate in the light of new knowledge, that it is inadvisable to use such titles. The time of life at which a disease occurs is clearly not one of the disorders that enters into the composition of the disease; but there is no objection to calling attention by the name of a disease to the time of life at which it occurs provided that it does occur solely at that time of life, and provided that we do not confuse it with similar diseases that may occur at other times of life. In fact, the names of most of the diseases that are denominated by the time of life at which they occur are open to one or other of these objections. Infantile diarrhœa does not materially differ from diarrhœa occurring at other times of life, nor is there a special "infantile" diarrhœa different from other diarrhœas that may occur in infants or adults. Gonorrhœal ophthalmia is more frequent in the newly-born, but no age is immune from it. Adolescent insanity and climacteric insanity have, it is true, their proper features, and the former title is unobjectionable, because that peculiar form of insanity does not occur at any other time of life, and no other form of insanity occurs in adolescents; but the term climacteric insanity is apt to mislead, and frequently does mislead, alienists into calling every form of insanity that occurs about the climacteric in women climacteric insanity, though women at that time of life are no more immune from other forms of insanity than men are.

A disease is always, as the article asserts, a single thing, a unified whole, an individual or unit. Yet, as has been said, it is always a group of things. Even in such a case as neuralgia, the pain alone is not the disease. Neuralgia, considered as pain *et preterea nihil*, is a symptom. Neuralgia the disease is more than this: it is the symptom plus a postulated intracorporeal cause, and it is the correlation of the symptom with an underlying cause that converts the symptom into a disease. A disease is an individual thing, but it is always a compound thing, and it is compounded by the mental operation of the observer. The constituents of the disease exist separately in the body and mind of the patient. Their combination into a whole is effected in and by the mind of the contemplator, and consists in the way in which he contemplates them. The constituents of the disease are either parted in space, like the clot in the brain and the paralysis of the limbs; or they are parted in time, like the hot fit and the cold fit of ague; or they are parted in nature, like the pain and the swelling of inflammation. The several factors that go to make up a disease are separate things, which in the patient exist apart, and have no unity until they are combined in the mind of the observer by his mental operation. The disorders are disorders of the same person, but in him they are not one, but many. What unity they have, other than what is imposed by the causal nexus, is a conceptual unity, a mental grouping, not a material propinquity. A disease is a group of things, but the things are collected together, not in space, nor in time, but in the mind, of the observer. A disease is a mental construct, and exists, not in the patient, but in the mind of the observer only. What exists in the patient is not a disease, but one or many disorders of function.

When we speak of a disease attacking a person, we are using a convenient figure of speech, but a figure of speech only. The person is atacked by bacteria, or protozoa, or what not; but he cannot be attacked by that which has no existence except in the mind of the observer. We may speak of a disease as arising within or affecting a person, but what arises in him and affects him is not a diease, but a disorder of some function, which is not a disease until the idea of it is combined in the mind of the observer with other ideas. The patient suffers also from the consequences and symptoms of this disorder of function; but these consequences and symptoms are not the disease. It is the combination them all that constitutes the disease, and this combination never exists in the body of the patient; for all the disorders are never present in him at the same time. The combination is in the mind of the observer: it is he who constructs the disease, which has no existence outside of his mind. When we speak of treating a disease, or of a disease getting better or worse, we are using convenient but inaccurate figures of speech. We do not administer drugs to the disease: we administer them to the patient. It is the patient, not the disease, that is put to bed, poulticed, formented, and bathed. It is the patient, not the disease, that gets better or worse, that recovers or dies. A disease in the human body no more has any existence *in rebus naturæ* or *in rerum natura* than a riot in the body of the community. When three or more persons behave violently in the street, we call the combination a riot; but there is no such single thing in the street as a riot. The riot is a mental construct. What exists in the street is a number of persons behaving riotously, and we mentally combine these several instances of riotous conduct into a single concept, and call the concept a riot. If a person is injured or killed in a riot, we do not say, nor can we think, that he was killed by the riot. He was killed by one or more of the rioters. The police do not charge or disperse the riot: they charge and disperse the rioters. It is easy in this case to see that the malady of the community is a mental construct and not a perceptible thing; and it is easy to appreciate because lawyers have strictly defined what they mean by a riot, and when they speak of a riot they know what they are talking about; but doctors do not recognize that a disease is a mental construct, because they have never defined a disease, and when they speak of a disease they do not, with all deference to them, know what they are talking about.

There are two other terms in medicine that clamor for definition. These are "functional disease" and "organic disease," which are commonly used as complementary and antithetic.

Every disease is of necessity functional, in the sense that it includes defect or disorder of function as an integral and necessary part of its composition. In fact, if we include in function the intrinsic as well as the extrinsic function, every disease consists entirely of disorders of function and of nothing else; and in this sense, every disease is of necessity purely functional. But in the common acceptation of the terms, do we mean, when we speak of organic disease, a disease in which there is structural damage that could be recognized on the post-mortem table or under the microscope, and by functional disease a disease in which no such damage could be found? This I think is the distinction that most people would formulate off-hand, but it is unquestionably wrong. Hysteria is the very type and example of what is called a functional disease, and in hysteria there are often structural changes correlated with the other disorders and therefore forming part of the disease. There may be wasting of muscles, shortening of muscles, deformities, changes even in ligaments and bones. Obviously, what is meant by a functional disease is not a disease which is unaccompanied by structural changes, but one in which the structural change, if present, is not correlating but correlated. It is a result, not a cause, of the disease. May we then describe a functional disease as a disease in which there is no structural basis, in which the cause of the whole combination of symptoms cannot be identified with any structural damage that can be found and recognized? Many would, I think, accept this as a good definition, but it is unquestionably wrong, for it would include among functional diseases epilepsy, chorea, neuralgia, infantile convulsions, and many cases of insanity, and none of these is ever considered a functional disease. Moreover, many "organic" diseases whose correlating structural basis is now known were considered to be "organic" diseases long before their structural basis was known.

I believe that what is meant by a functional disease is a disease in which not only can no correlating structural basis be found, but also no correlating structural basis is believed to exist. This would exclude from the class of functional diseases all the diseases just mentioned, for we undoubtedly believe that in them such a basis, exists, although we are unable to discover it. If this is so, and if there is no structural change as a correlating basis of the functional disease, what is the correlating basis? It is, or it is attributed to, the patient's imagination. I do not say that "functional" disease is the same as imaginary disease. It is not. It is clear that in hysteria the contractions and other disorders of nutrition are not imaginary. But what distinguishes the diseases that are called functional is that their correlating basis, their cause, is in the patient's imagination. A disease is a mental construct. It exists nowhere but in the mind of the physician; and consequently we find that many diseases, such as plethora, marasmus, biliousness, sluggish action of the liver, chill on the liver, and so forth, are wholly imaginary. But the physician holds no monopoly of imagination. The patient has his share; and if the physician can imagine a complete disease, the patient can imagine the basis of a disease, and not infrequently he does so. That the basis of certain "functional" diseases is in fact imaginary is shown by the fact that their symptoms may be anatomically and physiologically impossible. A paralysis or an anæsthesia, for instance, may be incompatible with the distribution of the nerves; and apart from supposition, no experienced physician can possibly doubt the existence of diseases whose basis is in the patient's imagination, and nowhere else. Taking hysteria as the type of "functional" disease, is is found that, whatever the subsequent symptoms may be, it always begins as an inability or incapacity; and there is no difficulty in conceiving that an inability or incapacity may be imaginary. The patient imagines that she cannot stand, walk, move her arm, apply her mind, endure noise or light, or do something else that she has always been able to do; and as long as she is convinced of her disability, it is a real disability. Undeceive her, and it disappears. That the causal nexus is in the imagination, and in that alone, is proved by the erratic distribution of the disorders. They do not correspond or fit in with any natural grouping of organs or functions. Anæsthesia of one arm may be correlated with paralysis of the opposite leg, and loss of half the field of vision in only one eye. Numbness of the little finger may accompany numbness of the thumb of the same hand. Such a distribution cannot be accounted for by any material cause. No structural change, whatever its nature, could correlate them all. The correlating cause must be the imagination.

By an "organic" disease, we understand a disease that is not of this nature. We may not know what the correlating cause of the disorders is, but we believe that it is not imaginary. We know that the correlating cause of some diseases is gross anatomical damage. Such diseases are certainly "organic." We know that the correlating cause of others is microscopical damage and such diseases also are certainly "organic." In a third class of diseases, such as epilepsy and neuralgia, we do not know the correlating cause. It may be some chemical aberration in the constitution of the tissue, or it may be something else; but we are quite confident that it is not anything imagined by the patient. Moreover, it is not and does not begin as a mere inability or incapacity. Such a disease is therefore excluded from the class of "functional" diseases, and included among the "organic."

I think that this description of a functional disease as one whose correlating basis is in the imagination of the patient helps us to understand why it is often so very difficult to distinguish "functional diseases" from pretended diseases; for they have in common that their origin is mental. In the one case the origin is in the imagination, but the disease is a true disease, and is curable by the ministrations of the physician. In the other case the origin is in the will, the disease is an imposture.

These, then, are the fundamentals of medicine that are here examined and defined.

1. *Function.*—The duty, office, work, or part that is performed by an organ or tissue.
2. *Extrinsic Function.*—The work done by an organ or tissue for the other parts of the body, or for the body as a whole: the part the organ or tissue plays in the bodily economy.
3. *Intrinsic Function.*—The maintenance and repair by an organ or tissue of its own structural integrity.
4. *Disease.*—Disorder of function. The wrong or defective execution of function, either extrinsic or intrinsic. Also the signs and results of such defect or disorder.
5. *Symptom.*—A perceptible sign or manifestation of disorder or defect of function.
6. *A Disease.*—A mental construct or concept, consisting of a symptom or group of symptoms correlated with or by a single intra-corporeal cause, known or postulated.
7. *A Sub-Disease* or *Symptomatic Disease.*—A symptom or group of symptoms correlated with or by a structural change which is part of an existing disease.
8. *An Infection.*—The invasion of the body by a living foreign agent which has the power of multiplication and distribution within the body, and may concentrate its attack on this or that part so as to give rise to a sub-disease of which the damage to that part is the correlating agent. (For the purpose in hand malignant disease is a foreign agent).
9. *Organic Disease.*—A disease whose correlating basis is believed to be material, that is to say a disorder of the structure or function of some part of the material body.
10. *Functional Disease.*—A disease which is believed to have no correlating basis except in the imagination of the patient.

How Eclipses Occur—I

And the Solar and Lunar Eclipses in 1917-18

By Frederick R. Honey, Ph. B., Trinity College

The prospect of seven eclipses in the year 1917, followed by three eclipses in 1918, of which one will be a total eclipse of the sun visible in the United States, makes the study of eclipses and their recurrence of unusual interest at this time. Since the total eclipse of the sun on June 8th, 1918, will be observed from a land area widely extended both in latitude and longitude, the presumption is a fair one that over this long path of the moon's shadow there will be weather conditions favorable for observations of the sun's corona.

The purpose of this article is to explain, by representations of the moon's motion in its orbit, the conditions which result in solar and lunar eclipses; and in order to make these conditions clear the graphic method is freely employed. The writer hopes that this method will approve itself to the reader, and induce him to pursue the study of astronomy in this way along more advanced lines.

In the study of astronomy, while it is impossible to form conceptions of the great magnitudes of the bodies considered and of the distances which separate them, it is a simple matter to compare the relative dimensions and distances. To this end, as far as practicable, the drawings are made to scale.

The study of eclipses is necessarily preceded by a brief description of the sun, the earth, and the moon, and of the movements of these bodies. The dimensions of the sun which controls the earth in its orbit and illumines its surface; of the earth the "moving observatory" from which all observations and measurements are made; and of the moon "our nearest neighbor" are shown in Plate I.

The Sun.—The great magnitude of the sun will be apparent on comparing its dimensions with those of the earth and the moon. The sun's diameter is more than 109 times that of the earth, and over 1,300,000 times its volume. Its diameter is 400 times the moon's diameter, and 64,000,000 times its volume. The sun is a great star which rotates on its axis in 25¼ days in the same direction as the revolution of the earth around it. It moves through space at a velocity of about 11 miles per second, carrying with it its satellites the planets. Its axis is directed to a point in the heavens midway between Vega and Polaris. Its rotation is demonstrated by the alternate appearance and disappearance on its surface of sun spots at regular intervals.

If a disk one inch in diameter be placed at a distance of 9 feet from the eye it may be held in a position where it will conceal the sun, and it will be apparent that it subtends a very small angle. This angle is a little over ½° which varies a little during the year. When the earth is nearest the sun in January the apparent diameter is a maximum (=0°.543); and in July when the earth is farthest from the sun the apparent diameter is a minimum (=0°.525), Plate 2, Fig. 1. Fig. 2, drawn to scale, represents the sun, the earth (a mere point) and the mean distance between them. The distances from the sun to a and b correspond respectively to the distances in January and July.

The Earth.—The earth is an oblate spheroid whose equatorial diameter is 7,926.68 miles, and polar diameter very nearly 7,900 miles; that is, the diameter at the equator is 26.7 miles greater than at the poles. The earth rotates about its polar axis which is directed to a point in the heavens about 1¼° from Polaris, and is inclined at an angle of 66°.55 to the plane on which the earth revolves around the sun, the plane of the ecliptic. Its position relative to this plane is shown at Fig. 3. The circles on its surface are the equator, the tropics, the polar circles, and the latitude circle of New York City (=40°.75 N). This parallel is selected because observations will be assumed to be made at this latitude. Meridians are represented at intervals of 2 hours or 30° of longitude ($=\frac{360}{12}°$.) The arrow a on the visible hemisphere shows the direction of the earth's rotation. The arrows z show the directions of the zenith at different points on the earth's surface. They are directly opposite at the poles and, at intervals of 12 hours, at the equator.

The Moon.—At its mean distance from the earth the full moon subtends an angle which does not differ very much from that subtended by the sun. But on account of the great eccentricity of its orbit as compared with that of the earth, the moon's apparent diameter when it is at perigee is very much greater than at apogee (Fig. 1). The difference between the mean apparent diameters of the sun and moon is shown by comparing their diameters and their distances. Thus comparing the diameters, $\frac{864392.02}{2159.92}=400.2$; and comparing the mean distances $\frac{92897416}{238862}=388.9$. A comparison of the distances from the earth of the sun and moon are illustrated at Fig. 4 which shows a small portion of the earth's orbit, the small circles representing the moon's orbit. The moon rotates slowly on its axis in the same direction as its revolution around the earth, making one rotation during this period. Thus only one hemisphere is visible.

Plate 1

The earth's diameter is $3\frac{2}{3}$ times the diameter of the moon ($=\frac{7913.33}{2159.92}$) and over 49 times its volume. But the density of the moon is not much more than 6/10 of the earth's density, making the earth's mass over 80 times that of the moon. As a consequence the center of gravity of the two bodies falls within the earth over 1,000 miles from its surface. In Fig. 5 the unit mass is that of the spherical body M, and the unit distance is 1,000 miles. The radius of the spherical body E is 4; and the mass of E (=80) multiplied by 3 = mass of M (=1) multiplied by 240. That is the center of gravity G is one unit (=1,000 miles) within the body E. These figures are easily remembered, and are given as rough approximations to the true dimensions and distances.

THE ECLIPTIC, THE EARTH'S ORBIT, AND THE MOON'S ORBIT

The Ecliptic.—In space there is no such thing as "up" and "down," or "perpendicular" and "horizontal." The position of a body and its direction of motion are referred to a plane whose position is assumed. It is the plane of the ecliptic, and for convenience it may be represented by this page placed in a horizontal position (Plate 3). It is called the plane of the ecliptic because an eclipse of the sun or moon can occur only when the latter is in or near this plane. As the reader looks down upon the plate it will be understood that bodies which are on the nearer side will be described as above the ecliptic, while those which are on the far side are below. This plane extended out indefinitely intersects the celestial sphere in a great circle which passes near certain stars, and it is desirable to become familiar with its trace on the celestial sphere as it appears to rotate around the earth once in 24 hours.

The Earth's Orbit.—The earth revolves around the sun in an ecliptic orbit with the sun at one focus. On account of the small eccentricity the orbit may be represented by a circle. The eccentricity is about 1/60 (=0.0167+), *i. e.*, the sun's distance from c the center of the orbit is about 1/60 of the mean distance between it and the earth =1,555,474 miles (=e) which is the linear eccentricity or actual distance. The length of the orbit, or distance traversed by the earth in one year of nearly 365¼ days is nearly 583.7 millions of miles. Each day the earth moves on the average a distance of 1,598,095 miles, which subtends at the sun an angle on the average of a little less than 1° ($=\frac{360°}{365.24}$). The velocity is 66,587 miles per hour; 1,110 miles per minute; or 18.5 miles per second.

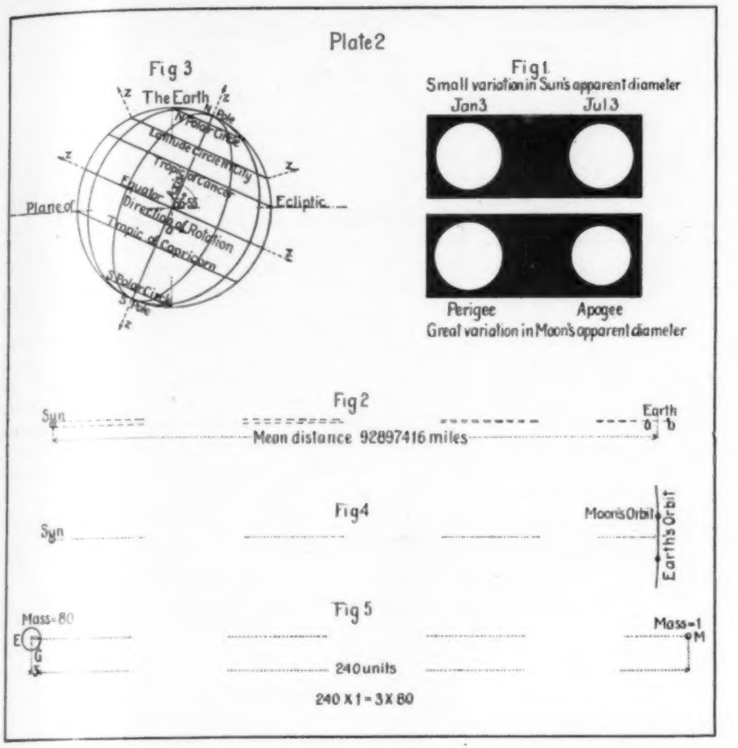
The Moon's Orbit.—The moon's orbit is an ellipse with the earth at one focus; but on account of "perturbations" the eccentricity is variable. It averages about 1/18, but it varies between 1/14 and 1/22. Any representation of it by an ellipse with a constant eccentricity must therefore be regarded as approximate. The moon's mean distance from the earth is 238,862 miles. One-eighteenth of this distance should be added and subtracted in order to obtain the distance of our satellite from the earth at the dates of apogee and perigee respectively. But the moon is frequently nearer to and farther from the earth than these figures indicate. On the assumption that the eccentricity is constant the length of the moon's orbit is 1,500,814 miles, a distance traversed in 27.32 days, *i. e.*, on the average 54,931 miles per day; 2,289 miles per hour; 38.15 miles per minute; and 0.636 miles per second. While the moon shares with the earth its velocity around the sun, its velocity relative to the earth is about one-thirtieth of the earth's velocity in its orbit.

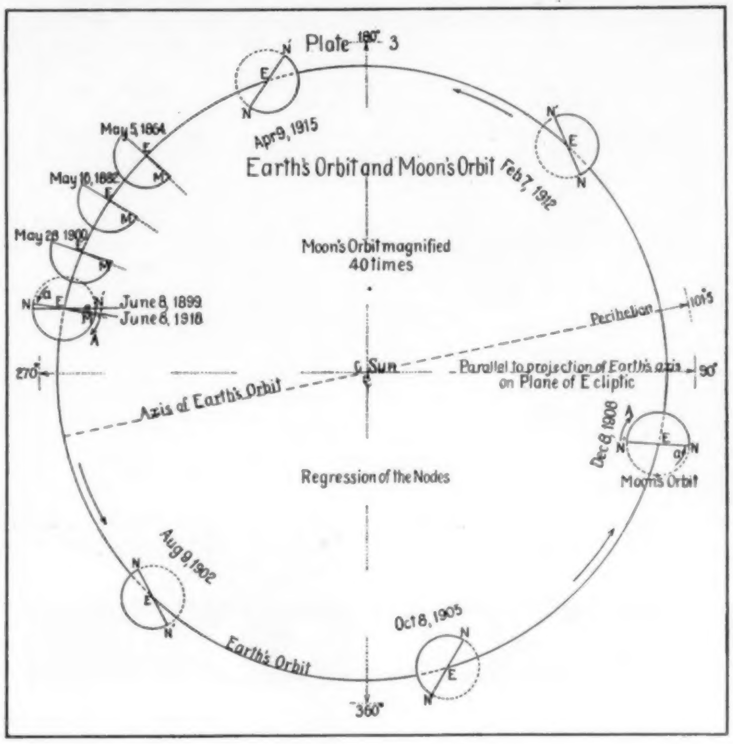
The plane of the moon's orbit is inclined to that of the ecliptic at an angle of 5°.15 and its intersection with that plane, or its trace, is the line of nodes N N¹. At N, the ascending node, the moon passes from the space below to that above the ecliptic; and at N¹, the descending node, it passes from the space above to that below. Thus during the moon's revolution around the earth it is for one-half the time above the ecliptic, and the orbit is represented by a full line. The dotted line represents the orbit below the ecliptic.

The arrow A shows the direction of the moon's motion which is the same as that of the earth's revolution around the sun and also of the rotation of the sun, earth, and moon on their axes.

Regression of the Nodes.—During the revolution of the moon's orbit around the sun it does not move into parallel positions, but it has a very slow retrograde motion in a direction contrary to that of the moon. The line of nodes N N¹ makes a complete rotation in the direction of the arrow A in less than 19 years. Its positions between the dates June 8th, 1899, and June 8th, 1918, are shown at intervals of three years and two months.

The positions of perigee and apogee revolve slowly in the direction of the moon's motion, making a complete revolution in about nine years, but this revolution is very irregular when it is observed at short intervals of time.





On account of the small angle of inclination of the moon's orbit its projection on the plane of the ecliptic differs a very little from its true form. The projection of a line on a plane is equal to its length multiplied by the cosine of the angle the line forms with the plane. The cosine of 5°.15 is 0.996, a diminution of only four-thousandths in the length of the radius which is perpendicular to the line of nodes, and when the radius coincides with the line of nodes it is of course represented in its true length. In a drawing of these dimensions the true form of the orbit and its projection practically coincide.

The Moon's Path in Space.—The moon's actual path in space, *i. e.*, its motion relative to the sun, is the resultant of two components, its revolution around the earth, and the earth's motion in its orbit. This is illustrated in Plate 4, Fig. 1, in which the orbits of the earth and moon are drawn to the same scale. The drawing shows a part of the earth's orbit for the month of March, 1918, and the positions of the earth from the 12th to the 30th. The small arrows show the direction of the moon's motion in its orbit, and the longer arrows the directions of motion of the earth and moon. The moon's positions are shown for each date, and the dotted line drawn through them is the moon's path which is always concave towards the sun. On the 12th the moon is between the earth and the sun (new moon); and on the 27th the earth is between the moon and the sun (full moon). In Fig. 2 the earth's orbit is plotted to a smaller scale, and the moon's orbit is magnified in order to show clearly the position of the moon relative to the earth at the dates of the phases, *i. e.*, March 12th, 19th, 27th and April 4th. In Fig, 3 the orbit is more highly magnified, and the moon's position is shown for each day from March 10th to April 5th. On the 12th the new moon is near perigee which accounts for its greater apparent diameter as compared with that of the full moon on the 27th when the distance from the earth is near its maximum. On the 19th, the date of the first quarter, the moon is very near the descending node N′, *i.e.*, it is below and not far from the ecliptic; and on April 4th, the date of the last quarter, the moon is above the ecliptic.

The moon's phases are shown at Fig. 4, which illustrates the variations in the moon's apparent diameter—diminishing and increasing as the moon's distance from the earth increases or diminishes.

OBSERVATIONS OF THE SUN AND MOON

The observer of the Heavens frequently finds it difficult to realize his varying position in space. He is accustomed to a certain land area which appears to be stationary, and it requires an effort of the imagination to realize that his zenith and horizon are continually changing. At two points on the earth's surface—the north and south poles—the observer's zeniths are stationary.

At any latitude, as for example that of New York city, the change of direction of the zenith during one-half of the earth's rotation is represented by the arrows (Plate 5, Fig. 1) the earth rotating in the direction of the arrow a. The horizon is perpendicular to the earth's radius which is the direction of the zenith. The southern horizon in each case is shown by an arrow. The arrows parallel to the ecliptic are the directions in which the sun is seen at noon at the dates of the summer and winter solstices when the earth is at opposite points in tis orbit. Meridians on the earth's surface are represented at intervals of 3 hours corresponding to 45° of longitude. The arrow parallel to the ecliptic, strictly speaking, gives the direction in which a point on the sun's surface above the ecliptic is seen. The distance from this point to the eclipitic however is very small in comparison with the sun's radius. The arrow may be assumed to be directed to the sun's center since the distance is so great that the angle formed by the visual ray with the ecliptic is small enough to be inappreciable in the drawing. In the position A it is a little less than the solar parallax (=8″.8); and in position B it is considerably less. It will be understood that a very distant object situated in the ecliptic will be seen in a direction which may be represented by a horizontal arrow. The sun's altitude above the horizon at noon on June 22d is represented by a, its maximum value. This angle gradually diminishes until December 22d when the sun is seen in the opposite direction, and the altitude reaches its minimum value β. The horizontal arrow in position A is the direction in which a very distant object will be seen when crossing the meridian at midnight at the date of the summer solstice; and in position B at the date of the winter solstice.

Fig. 2 shows the directions of the zenith, the southern horizon, the line of vision, and the 3-hour circles, at the dates of the vernal and autumnal equinoxes. The sun's altitude a is shown in projection and the true value may be obtained by a simple geometrical construction. It is between the values a and β in Fig. 1. In positions C and D the horizontal arrows show the direction in which the sun is seen at noon at the dates of the vernal and autumnal equinox respectively and also that of a very distant object crossing the meridian at midnight at the dates of the equinoxes.

Figs. 3 and 4 represent the earth, the moon, the mean distance between these bodies, and the maximum distance of the moon above and below the ecliptic drawn to scale. The possible variations of the moon's altitude (=a) when crossing the meridian at midnight at the date of the winter solstice are shown in Fig. 3; and those at the date of the summer solstice in Fig. 4. The moon's altitude varies between the maximum value of a in Fig. 3 and its minimum value in Fig. 4, and is determined by the position in its orbit.

THE SHADOWS OF THE EARTH AND MOON

The determination of the form and length of the earth's shadow would be a simple matter were it not complicated by the presence of the atmosphere which is dense at the earth's surface and which appreciably adds to the diameter of the body casting the shadow. Astronomers differ somewhat as to the effective diameter. The complexity of the subject is due to the fact that the atmosphere becomes rarer as its distance from the earth's surface increases. It should also be remembered that the sun's rays are refracted twice in passing through the atmosphere. This is proved at the time of a total eclipse of the moon when its surface is partially illuminated by the refracted rays. Otherwise the eclipsed moon would be invisible during the period of totality.

The form of the shadow is conical, and its surface is limited by solar rays which are tangent to the sun and the earth. Fig. 1, Plate 6, exhibits at a glance the proportion between the dimensions of the sun, its distance from the earth, and the length of the shadow. The earth itself is reduced to a mere point.

If the earth were deprived of its atmosphere the length of its shadow would be determined by the proportion R:r::D+x:x in which R and r are the radii of the sun and earth, and D is the mean distance from the sun to the earth. The length of the shadow $x=\frac{rD}{R-r}$. Assuming that the earth is a sphere whose radius is a mean between the equatorial and polar radii, the length of the shadow is 858,313 miles. The length reaches its maximum when the earth is at aphelion in July and its minimum when the earth is at perihelion in January.

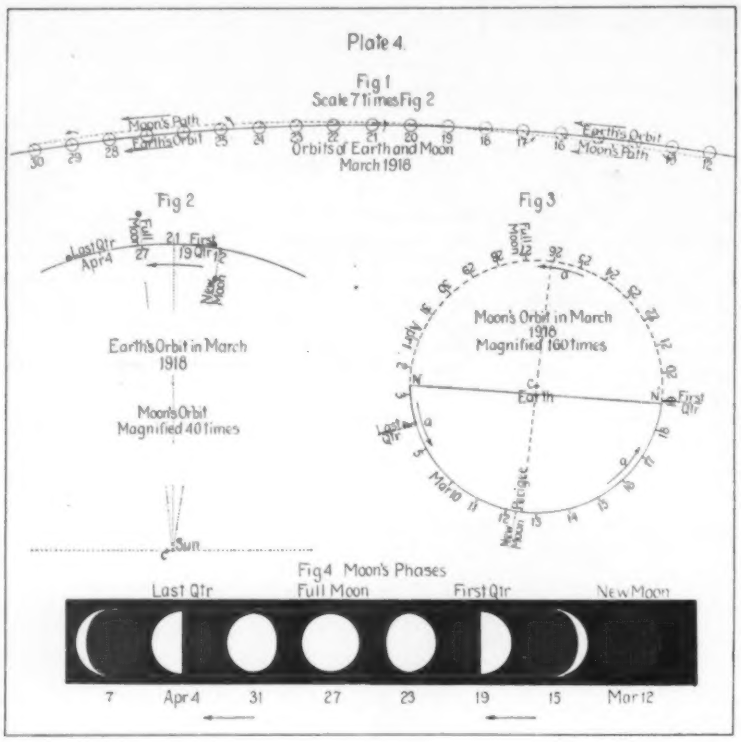
The length of the moon's shadow is found by the same formula, making r equal to the moon's radius. The length is 232,711 miles, and Fig. 2, drawn to scale, represents the earth, the moon, the shadows, and a b, the section of the earth's shadow through which the moon passes when eclipsed.

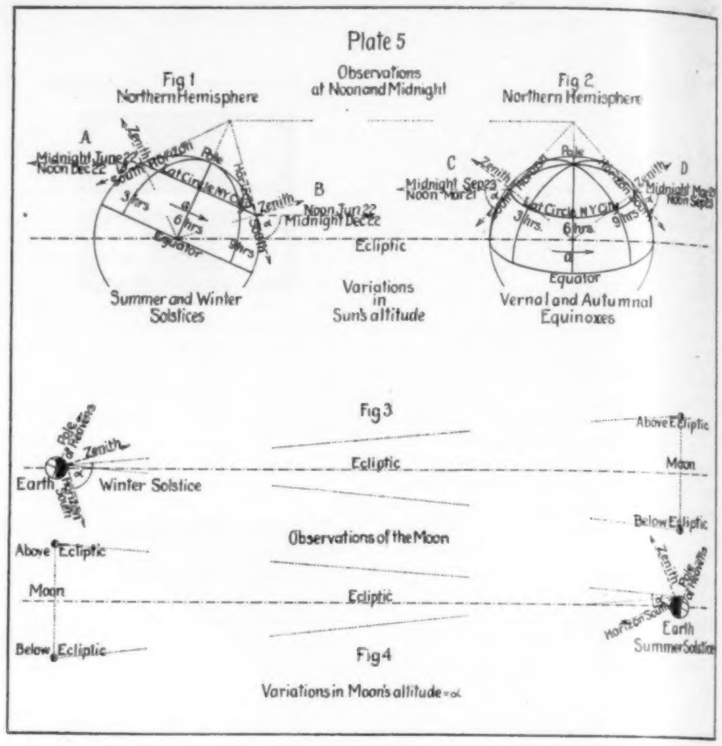
On account of the moon's variable distance from the earth, its shadow in a central eclipse may or may not reach the earth's surface. When the length of the shadow is less than the moon's distance the eclipse is annular; when it is greater the eclipse is total, Fig. 3.

HOW ECLIPSES OCCUR

Lunar Eclipses.—A lunar eclipse occurs at the date of full moon, and when the moon is at or near a node of its orbit. If it is at the node, that is if it is in the plane of the ecliptic, the moon crosses the earth's shadow centrally. If it is above the ecliptic it crosses the upper part of the shadow section; if it is below it crosses the lower part, Fig. 4. The center of the circle which represents the earth is the projection of the line of nodes on the plane of the paper. The ascending node N is on the near side of the orbit, and the descending node N′ on the far side. The arrows a and a′ indicate the directions of the moon's motion on opposite sides of the orbit. The earth's shadow is very much foreshortened. Its axis forms with the plane of the paper an angle of about 87°, and its projection is 1/20 of its length (cos 87° = 0.0523). The shadow on the right whose votex is V′ is on the far side of the earth; and the section through which the moon is passing represents its diameter where it crosses the orbit. On the left the shadow whose votex is V is on the near side, and is in the opposite direction.

Solar Eclipses.—In order that an eclipse of the sun may be observed on the earth's surface the moon must be within, or partly within the area of a cone which is tangent to the sun and earth. If it touches the surface of this cone the moon would appear to an observer at





0 to graze the sun's limb, Fig. 5. The distance from the moon's center to the ecliptic is a b, and this determines the point a¹, the position of the center on the orbit, making a¹b¹ = ab. From this it appears that an eclipse is possible only when the moon's distance from the node is less than a¹N either above or below the ecliptic. In a partial eclipse the moon is partly within this conical area; in a total or annular eclipse it is wholly within this area. The path of the moon's shadow in a total eclipse is determined by the moon's position relative to the ecliptic, and also by the earth's position in its orbit.

(To be continued)

Directing an Attack

In former times the orders and instructions from commanding officers were commonly communicated to the units of their forces by messengers or by flag signals, but this like most other details of military practice has now been changed as a result of the new campaigning methods that prevail in Europe. With an army strung out over miles of irregular trenches prompt communication by the older method is obviously impossible, although special instructions carried by fast motorcycles have been found greatly superior to the old horse-mounted messengers; but where rapid communication with the commanders of long lines of trenches, and numerous widely scattered batteries of guns, is necessary something vastly more prompt and certain is required, and in this emergency recourse is had to the telephone, which has proved to be indispensable. By means of telephones, operated through heavily insulated wires that can be run rapidly from point to point, resting directly upon the ground without any supports or elaborate fixtures, orders may be transmitted along miles of trenches within a few minutes, where flags could not be seen, and where messengers even on the fastest motorcycles would require hours, even if they got through safely at all, thus enabling rapid coöperative action to be taken, or special advances organized and properly supported both by troops and guns.

As an adjunct to the telephone the electric buzzer has been found extremely valuable, as it will often operate in cases where the insulation is defective owing to injuries to the wires, or from other causes; and in such cases the telephone aids in distinguishing weak buzzer messages, which are transmitted by the continental telegraph code. Everywhere on the front there can be found elaborate networks of these communicating wires; and when there is a change in the lines of trenches it is a simple matter to coincidentally reel up any discarded line and run out a new one, so that communication is practically never interrupted. In operating these means of communication much ingenuity is developed, and many bits of apparatus are improvised to meet emergencies. One such case on the French lines is cited, where a switch boards to serve five stations was quickly constructed from material picked up on the spot. Metal from an 18 pdr. cartridge case was secured upon a board with screws taken from an ammunition box. The plugs were .303 rifle cartridge cases, while fuse pins and various bits of wire completed a very practical and satisfactory outfit that performed most valuable service.

Besides enabling communications to be transmitted rapidly between established positions there is another occasion where telephone lines are most valuable, but unfortunately by no means invulnerable, and this is in the case of an advance of attacking troops. Preliminary to such an advance the way is prepared by heavy artillery fire, during which it is common to throw a number of smoke producing bombs to produce a heavy black cloud that shall conceal the advance of the troops when the final dash is inaugurated. As the men advance it is most desirable that communication be maintained with the heavy gun batteries, far in the rear, to tell them how to direct their fire so as not to drop shells among their own men as the enemy is driven back; and here the telephone, and its accompanying buzzer has done great service, although owing to the liability of the wires being destroyed by exploding shells has caused many serious catastrophies.

The illustration on the first page of this issue shows how the telephone squad works on the occasion of one of the above mentioned advances of the forces. Closely following the troops, as they clear their own trenches, comes the officer in charge of communications, and he is here seen running forward, carrying his field telephone ready for service in the case in his right hand. With him go men carrying reels of insulated wire, which they pay out as they run; and as often as is necessary the wire is connected to the instrument, and information sent back to a main station in the trenches as to the location and conditions where the fighting is going on. One of the linemen carries an extra telephone for use in case of accident to the instrument carried by the officer in charge; and with the two reels of wire coupled together communication can be extended for a long distance.

One of the recent refinements introduced at battery stations is the loud speaking telephone which puts the battery commander into direct communication with those he is directing. Outfits of this kind are arranged in a very compact form so they can be easily transported and quickly installed, a typical set consisting of a transmitter, receiver, horn, induction coil, buzzer, key jack, wiring and a local battery that weighs but three and a half pounds complete.

Potatoes as Food

The general use of potatoes in the average family and the better customs prevailing in many homes in preparing the tubers for food are based on sound economic and dietetic reasons, according to specialists of the Office of Home Economics of the United States Department of Agriculture. Studies of the preparation and use of potatoes as food are reported in Department of Agriculture Bulletin No. 468, recently issued.

Potatoes are easy to cook in a variety of ways. From the point of view of dietetics, they furnish starch in one readily digestible form, contain mineral substances of importance to the body, and—a fact less generally known—tend to make the tissues and fluids of the body alkaline, so counteracting the tendency of meats, eggs, fish, and like foods to create acid conditions. Since the body does its work best when its condition is either neutral or slightly alkaline, potatoes, like most vegetables, perform an important function in the diet besides furnishing energy-producing material. This scientific fact justifies the custom that is prevalent in many families of serving a goodly supply of potatoes or other vegetables with each helping of meat.

Potatoes, however, while a valuable addition to a mixed diet, alone are not suited to meet the needs of the body because of their poverty in proteins and fat. Of these latter important elements protein is furnished in meats, eggs, fish, milk, beans, and similar foods, and fat in butter, bacon, table oils, and the fats and oils used in cookery.

Greater care than commonly is exercised should be taken in peeling potatoes. Very often 20 per cent of the potato is pared away. This results not only in the waste of considerable potato, but also in the loss of one of the most valuable portions of the tuber, since the soluble mineral salts are present in the material near the skin, which would be removed and thrown away. These salts can be preserved by a more careful removal of the skin, as by shallow paring or rubbing, and also by boiling or baking the potatoes in their jackets.

Paring before boiling, however, may be the most desirable method of cooking potatoes, which through an undue exposure to light may have acquired a bitter taste, or those which have been kept until late in the spring, since in this way more of the disagreeable flavor is eliminated. Such potatoes may also be soaked before cooking.

While these methods may be desirable with potatoes which have been exposed to light, they result in the loss of considerable food value without compensating advantages when applied to new or well-matured potatoes. If such potatoes are boiled after paring, they should be dropped into boiling water instead of being placed on the stove in cold water. By the latter method there is twice the loss of protein, or tissue-building elements, resulting from the former. The loss of mineral matter is about the same by each method. There is no loss of starchy material in boiling unless portions of the tuber break off.

Practically the only loss when potatoes are baked in their skins is of the water which escapes as steam. The more or less common custom of pricking holes in the skin of baked potatoes or breaking them is explained by the fact that unless the steam which is formed inside the skin is allowed to escape it will change back into water and produce sogginess.

Potatoes which have turned green and have sprouting tubers present a considerable quantity of solanin, an acrid poisonous substance which, though not dangerous in the quantities ordinarily met with, gives a disagreeable flavor. It is best, therefore, to avoid such potatoes or to cut out green or sprouting portions.—*Weekly News Letter, Department of Agriculture.*

New Evidence in Regard to the Instability of the Human Types*

By Franz Boas, Department of Anthropology, Columbia University

A number of years ago I carried on, under the auspices of the United States Immigration Commission, an investigation on the physical types of immigrants and of their descendants. One of the results of this inquiry was the establishment of the fact that there is a difference in appearance between the immigrants and their descendants. So far as the bulk of the body is concerned, this information was not new. Analogous phenomena had been observed in 1877 by H. P. Bowditch in Boston, and by Peckham in Milwaukee. It was new, however, that there is also a change in such features as the cephalic index and the width of the face. It was found that on the average the heads of descendants of immigrants of East European types are more elongated, and those of the descendants of South Europeans more rounded, than those of their parents. The data were obtained partly by a generalizing method, partly by a comparison between parents and children.

The results of this inquiry have been attacked by many writers, on the basis that they decline to believe that such changes can occur. I have not found any actual criticism of my method and of the results, except by Corrado Gini, who doubts the inferences drawn in regard to the populations of Italian cities which also show a modification of the cephalic index.

I think the hesitation of many authors to accept the results is due largely to a misinterpretation of their significance. I may be allowed to state concisely here what I think has been proved, and what inferences seem justifiable.

The investigation has a direct bearing upon the question of the classification of human local types, more particularly of European types. Many attempts have been made to give a satisfactory classification of the divergent types that occur in Europe. Pigmentation, stature, form of the head, and form of the face, show material differences in various parts of Europe, notwithstanding the fundamental sameness of the whole race. Authors like Deniker, and many others, have carried out on this basis an elaborate classification of European types in a number of "races" and "subraces."

In this classification the assumption is made that each race that we find at the present time in its particular environment is an hereditary type different from the others. In order to express this assumption, I should like to use the term that these races and subraces represent, "genetic" types—genetic in the sense that their characteristics are determined by heredity alone. The question, however, has not been answered, whether these types are really genetic types, or whether they are what I might call "ecotypes," in so far as their appearance is determined by environmental or ecological conditions. If we include in this term not only environmental conditions in a geographical and social sense, but also conditions that are determined by the organism itself, we might, perhaps, still better call them physiological types, in the same sense in which the biologist speaks of physiological races. My investigation then was directed to the question in how far a certain type of man may be considered a genetic type, in how far a physiological type. If there is any kind of environmental influence, it is obvious that we can never speak of a genetic type *per se*, but that every genetic type appears under certain environmental or physiological conditions, and that in this sense we are always dealing with the physiological form of a certain genetic type. The question, then, that demands an answer, is, in how far genetic types may be influenced by physiological changes.

I believe, that, on the basis of the material that I collected, we must maintain that the same genetic type may occur in various physiologically conditioned forms, and that so far as stature, head-form, and width of face are concerned, the differences between the physiological forms of the same genetic type are of the same order as the differences between the races and sub-races which have been distinguished in Europe. I must add, however, that these remarks do not refer to pigmentation, for, contrary to a widespread belief, we have no proof of environmental influences upon pigmentation. For this reason the classification of European races cannot be considered as proving genetic differentiation.

The whole investigation which I carried on, and certain comparable observations obtained from older literature, do not indicate in any way to what physiological conditions the observed changes may be due. The only physiological causes in regard to which evidence is available relate to the bulk of the body, and to a certain extent to the proportions of the limbs. The size of the body depends upon the conditions under which growth takes place. Growth depends upon nutrition, upon pathological conditions during childhood, and upon many other causes, all of which have an effect upon the bulk of the body of the adult. When these conditions are favorable, the physiological form of a certain genetic type will be large. If there is much retardation during early life, the physiological form of the same genetic type will be small. Retardation and acceleration of growth may also account for varying proportions of the limbs. On the other hand, we have no information whatever that would allow us to determine the cause of the physiological diminution in the size of the face that has been observed in America, nor for the change in the head-index that occurs among the descendants of immigrants.

Furthermore, there is nothing to indicate that these changes are in any sense genetic changes; that is to say, that they influence the hereditary constitution of the germ. It may very well be that the same people, if carried back to their old environment, would revert to their former physiological types.

In fact, it can be shown that certain features are strictly hereditary, and that, although the physiological form of a genetic type may vary, nevertheless the genetic type as such will exert its influence. Prof. von Luschan has repeatedly called attention to this fact as revealed in the modern populations of Asia Minor, where, notwithstanding the mixture which has continued for at least four thousand years, the characteristic Armenian, Northwest European, and Mediterranean types survive in the mixed population. Similar examples may be observed in Italy. I have calculated the variability of the head-form that is found in different parts of Italy, based on the data collected by Ridolfo Livi. The head-form of the North Italians is excessively short. The head-form of the South Italians is decidedly elongated. In between we find intermediate forms. In the Apennines, we have, in addition to the mixture of these two Italian forms, a marked immigration from the Balkan Peninsula, which introduced another short-headed type. As a result of these long-continued mixtures, we observe low degrees of variability in northern and southern Italy, high degrees of variability in the central regions, particularly in the Abruzzi. These indicate permanence of the component types of the mixed population.

During the last few years some new data have been collected that confirm my previous observations. I have pointed out several times that changes of types have been observed in Europe wherever a careful comparison between city population and country population has been made. Generally the changes that occur there have been ascribed to selective influences; but the intensity of selection would have to be so great, that it does not seem plausible that they can be explained by this cause.

In conjunction with Miss Helene M. Boas, I have made a comparison between the head-forms of the city populations of Italy and of the rural populations in the areas surrounding the cities, and compared these data with the information given in the Italian census in regard to the immigration into cities. I found throughout that the variability of head-form in each city is smaller than would be found in a population in which all the constituent genetic types were present without physiological modification. This result has been criticised by Corrado Gini, on the basis that in former times migration was less than what it is now. I grant this point; but nevertheless it is quite obvious, that, although no exact data are available, the mixture of population in a city like Rome or like Florence must be very great, since the political conditions for the conflux of Italians, and even of individuals from outside of Italy, have been favorable for a very long period. If this is true, we should expect a very high degree of variability in Rome, which, however, is not found.

Turning to new data, I wish to mention the observation made by Dr. Hrdlicka, who, in a paper read before the Pan-American Scientific Congress, has stated that he found the width of face of Americans of the fourth generation—that is to say, of descendants of Europeans who had no foreign-born ancestor after the fourth generation back—was materially decreased as compared to the width of face found among European types. This conforms strictly with what I found among the descendants of immigrants of all nationalities.

A year ago I had the opportunity to make an anthropometric investigation of a considerable number of natives of Porto Rico. This work was carried on in connection with the Natural History Survey of Porto Rico organized by the New York Academy of Sciences. The population of Porto Rico is derived from three distinct sources—from people belonging to the Mediterranean type of Europe, from West Indian aborigines, and from Negroes. The Mediterranean ancestry of Porto Ricans leads back to all parts of Spain; but among the more recent immigrants, Catalans, people from the Balear Islands and from the Canary Islands prevail. There are also a fair number of Corsicans. The Spanish immigration has been quite strong even up to the present time. Among the individuals whom I measured, fourteen per cent had Southern-born fathers, some even Spanish-born mothers. From all we know about the history of the people of Porto Rico, we must consider them essentially as descendants of male immigrants who intermarried with native women. It is evident that in early times this must have led to the development of Mestizo population, in which, however, the amount of Indian blood must have decreased very rapidly, owing to the continued influx of Spanish blood, and the elimination from the reproductive series of the male Mestizo element. The Negro population is settled particularly on the outer coast of the island; while the amount of Negro blood in the interior is apparently not very great, except near the principal routes of travel.

According to European observations, the Spanish ancestors of this population, while living in Spain, are long-headed. The Negro element is of mixed provenience, from many different parts of Africa, but, on the whole, the Negro in Africa is also long-headed. The West Indian element, judging from the few prehistoric crania that have been recovered, represents a very short-headed type. The modern Porto Rican is short-headed to such a degree that even a heavy admixture of Indian blood could not account for the degree of short-headedness. If we apply the results of known instances of intermixture to our particular case, and assume stability of type, we find that, even if the population were one half Indian and one half Spanish and Negro, the head-index would be considerably lower than what we actually observe. There is therefore no source that would account for the present head-form as a genetic type; and we are compelled to assume that the form which we observe is due to a physiological modification that has occurred under the new environment. The head-form of those individuals whose fathers were born in Spain is noticeably more elongated than that of the individuals whose parents are both Porto Ricans. The head-index of the Mulatto population is intermediate between the index of the native Porto Ricans and that of those whose one parent is Spanish. The average index of the Porto Rican is 82.5. The average index of the Spaniard in Spain is less than 77. We find, therefore, an increase of five units here, which can in no way be accounted for by genetic considerations.

I may mention in this connection that the average stature of the Porto Ricans is apparently almost the same as that of the Sicilians in New York, and that throughout the period of growth the stature follows about the same curve as that represented by Sicilian children living in America. If anything, the stature is a little lower, and there is no indication of that acceleration of development which is so often claimed to be characteristic of a tropical environment. Undoubtedly poor nutrition, and probably also pathological causes, have a retarding influence here, which might easily be overcome by better hygienic conditions.

It is unfortunate that we have no accurate statistics of Porto Rican immigration and emigration, which would enable us to state with much greater definiteness what genetic type should be expected here. There is a popular belief in Porto Rico that in certain parts of the island, in the so-called "Indiera," Indian types have persisted to a greater extent than elsewhere. I have not been able to find any definite indication of a difference in type; but I have measured only a few individuals from these districts. The material that I have been able to study comes from all parts of the island, but principally from the western-central part. The phenomena here described occur with equal intensity in all parts of the island.

The question of the degree of instability of human types seems to my mind an exceedingly important one for a clear understanding of the problems of physical anthropology. It would be particularly desirable to study the problem among immigrants living in different rural communities of the United States, and it would be even more desirable to have information in regard to the types that develop among the East Europeans and South Europeans who return to Europe and settle in their old geographical environment.

*A paper read before the National Academy of Sciences, and published in the *Proceedings* of the Society.

Regulating grade by picks, road roller and grading machine on Commonwealth Avenue, Boston

Columbia River Highway—spreading and rolling of wearing surface on broken stone foundation

Stone and Concrete Road Foundations*

From the Standpoint of Efficiency and Economy

By Geo. C. Warren

"Economy and Efficiency" have come to be commonly used together as a high sounding expression of which one almost stands in awe. "Economy" is defined in the dictionary as "A frugal and judicious use of money, material, time, etc.; the avoidance of freedom from waste or extravagance in the use of anything." Surely that embraces efficiency.

"Efficiency" is defined as: "Production of or the capacity of producing the effect intended or desired." Surely that embraces economy. "Economy and Efficiency" therefore, in their broad sense, each embrace the same qualities and, taken together, add nothing to either, except a certain awe-inspiring effect, about as the famous expression of one of our celebrated late ex-Presidents, "innocuous desuetude" is more awe-inspiring than "harmless disuse."

To my mind, with all its grandeur, "Economy and Efficiency," in its most extreme application, is well embraced in the one little word "best," when that word is used in its broadest sense of "all things considered."

An engineer who would say that any one type of road or pavement foundation or surface is "best," or "most efficient and economical" under all conditions, would be like an architect who should say either stone, brick, concrete or lumber is the best building material for all conditions. One would class such an architect as a man of "one idea" and incapable of giving sound advice from points of view of either true economy or efficiency.

The subject on which I was requested to address you this evening was: "Broken Stone *vs.* Cement Concrete Foundations, from the Standpoints of Efficiency and Economy." This seems to carry the idea, like a lawsuit, that there is room for argument on two sides, but only one right side. I have, therefore, slightly changed and broadened the title to: "Stone and Concrete Foundations, from the Standpoint of Efficiency and Economy."

In my judgment the question of "best" or most "economical and efficient" pavement foundation (as to both character and depth) to meet any particular conditions, necessarily entails a careful study and considerations of those conditions in each case, particularly including: Character of subsoil; character of traffic; character of wearing surface to be laid on the foundation; climatic conditions.

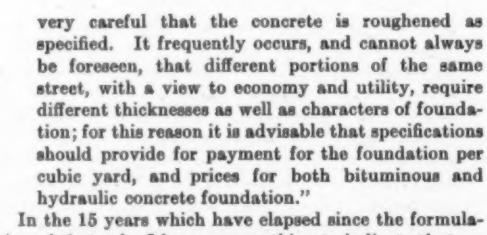
As a general statement, applied to new pavements, that is, streets or roads having no pavement or foundation which can be efficiently used as a foundation for a new wearing surface, I think a statement applied to this subject by the company with which I am associated, in its instructions or advice 15 years ago and maintained at all times since then, covers the ground as well as it could be covered in a few words, and is as follows:

> "*Sub-Soil.*—An unyielding foundation is essential. Our specifications for Bituminous Base are designed for characters of sub-soil which can be rolled to provide a firm sub-foundation. Where unyielding sub-soil conditions do not exist, or where the roadway is so narrow or contains such obstructions as to make proper rolling of foundation impossible, the use of hydraulic concrete is recommended, being very careful that the concrete is roughened as specified. It frequently occurs, and cannot always be foreseen, that different portions of the same street, with a view to economy and utility, require different thicknesses as well as characters of foundation; for this reason it is advisable that specifications should provide for payment for the foundation per cubic yard, and prices for both bituminous and hydraulic concrete foundation."

In the 15 years which have elapsed since the formulation of that rule, I have seen nothing to indicate that, as between crushed stone and hydraulic cement concrete foundation, it is not absolutely correct, except as noted below in the case of sandy subsoil under certain conditions. I, however, freely confess that I have seen many cases of:

1. Misjudgment and the use of crushed stone foundation under subsoil and other local conditions where such a foundation should not have been specified and:

2. Where expensive concrete foundation has been adopted under subsoil and other conditions which make such adoption a lack of true economy to an extent that, to my mind, constitutes incompetence.



A bituminous road laid over old macadam

In discussion of this matter I propose to consider "concrete" as including any dense aggregate ranging from coarse to fine, the particles of which are bound together by any cementing agent, whether hydraulic cement, bituminous cement or other cement.

BLOCK PAVEMENTS

At the outset I will assume it to be a pretty generally recognized fact that all forms of block pavement must be laid on concrete base for the reason that broken stone base does not provide a bed on which the blocks can rest without danger of rocking under traffic.

Incidentally, I believe it will also be generally conceded that, unless the blocks are more completely and firmly grouted than is practicable on the entire area of pavement, it is necessary that the depth of concrete foundation shall be greater than the foundation for a monolithic wearing surface. This, because in the case of the block pavement the weight transmitted to the foundation is that of the load necessarily resting on individual block areas, while in the case of monolithic surfaces the weight of the same load transmitted to the foundation is distributed over many times greater area.

We will, therefore, consider that the question of use of broken stone foundation is practically limited to monolithic wearing surfaces.

BROKEN STONE FOUNDATIONS

Each individual case should be given special consideration with special reference to the character of subsoil and climatic conditions. If the subsoil is of the nature of clay and the climate such that the sub-base is liable to become wet before the waterproof pavement surface is laid, then it is unsafe to specify broken stone base, because in such wet, yielding condition the subsoil does not provide a sub-grade over which either the crushed stone or bituminous surface can be properly compressed.

If, on the other hand, the subsoil is of a gravelly nature, or if in a climate where it seldom or never rains during the working season, no more serviceable nor equally low cost foundation can be produced for a stable bituminous wearing surface than a thoroughly rolled crushed stone. This has been abundantly proven in many cases.

If, however, the subsoil is of a gravelly nature through which water will drain with reasonable rapidity, the factor of dry climate becomes one of little importance in consideration of the type of pavement foundation.

SAND SUBSOIL

Nearly sixteen years ago we had great difficulty in securing a solidly compacted broken stone foundation on the sandy soil of one of the lake cities of Indiana. The spreading of marsh grass over the sandy sub-grade before spreading the crushed stone helped immensely.

During the present year, however, we met an interesting case in connection with the building of bitulithic pavement on the "Interstate Bridge" crossing the Columbia River from near Portland, Oregon to Vancouver, Wash., and the bridge approaches. The bridge floor is 21,624 square yards and the pavement laid on heavily reinforced Portland cement concrete foundation. The bridge approaches aggregate 46,320 square yards or about three miles in length and are formed of sand pumped from the Columbia River, the fill thus made having depths varying from five feet to twenty-five feet. Being washed in place the sand fill is compressed as solidly as possible. The specifications required a broken stone base laid on this sand fill. The general belief is that under such conditions the crushed stone in rolling will compress several inches into the dry sand and even then not be solidly compacted. It has, however, been proved that a generous amount of water used to wet the sand during the process of spreading and rolling the base, provides a sub-grade so solid that the stone compresses into it but very slightly, and becomes solidly compacted under the twelve ton steam roller and, using the same heavy roller, no trouble develops in compression of the bitulithic wearing surface.

Here we have a useful application of the well known scientific fact that on the beach dry sand cannot be traversed by the lightest vehicle, while sand combined with more water than will fill the voids in the sand, will itself flow and not hold up the weight of a load. Sand from which the surplus water has drained away, leaving just enough water to fill the voids, will sustain a quite heavy load.

So on the bridge approaches, the artificial application of water to the surface of the sand fill results in an excellent sub-grade for broken stone foundation.

*From a paper delivered before The American Society for the Advancement of Science (Section D), at the Auditorium of The Automobile Club of America, New York City.

Hartford-Saybrook Turnpike, Cromwell, Conn., under eight feet of water during flood, laid on macadam foundation

The same road after the flood. It has been under water four times and shows no signs of injury

Economic utility of broken stone foundations is especially applicable in the case of old macadam country roads or city streets, the grade and contour of which are such that they can be regulated without serious disturbance of the old macadam.

It is a well established fact that with a dense, stable, waterproof pavement surface, a rolled crushed stone base practically overcomes the cracking of Portland cement concrete. It is also self evident that crushed stone foundation has the important economic advantage that in the case of broken stone base the bituminous wearing surface under pressure of the roller fills the chinks in the surface of the foundation and forms an important union between the foundation and surface.

This brings us to the second phase of our subject:

CONCRETE FOUNDATIONS

which are divided into three general classes, to wit: Portland Cement Concrete; Bituminous Cement Concrete; Concrete bound together by other classes of cement.

We will consider this only on the basis of *true* concrete, as all concrete should be considered; that is, a dense mass of coarse and fine aggregate in which the coarse aggregates predominate and the finer aggregates are in approximately the proportion to fill the voids or air spaces between the coarser particles—approximately one-half to two-thirds of the total being coarse aggregate.

If the cemented aggregate does not measure up to this test then we have mortar, or at least a small percentage of coarse aggregate "floating" in a surplus of mortar and not an "economical and efficient" concrete.

As previously stated, in cases of weak sub-base, solid dense concrete as described has an important advantage in that, by bridging over the weak sub-base it imparts a greater strength than is possible with rolled crushed stone under such circumstances. Taking the subsoil conditions throughout the United States and Canada as a whole, in a large proportion of cases doubtless, the subsoil and climatic conditions are such as to make the use of concrete desirable, but as noted above, this is not at all a universal rule.

Well made Portland cement concrete base of the conventional proportions of 1 part cement, 3 parts fine aggregate and 6 parts coarse aggregate, has a greater crushing and tensile strength than either broken stone or other types of concrete, but it is well established that a slab of Portland cement concrete laid on more or less damp subsoil will necessarily crack, and, where cracks occur in the foundation, then cracking of the pavement wearing surface is sure to follow. In many cases such cracking is the lesser of two evils and in such cases there can be no doubt but that Portland Cement concrete is the best and, therefore, the most economical and efficient pavement foundation, but this condition is not at all universal.

Bituminous concrete, *i. e.*, concrete in which the well proportioned coarse and fine aggregate, which may be either natural gravel and sand or crushed stone and sand heated and mechanically mixed with suitable bituminous cement and spread and rolled on the previously compacted sub-grade, has the extremely important advantage of overcoming the cracking of Portland cement concrete foundations. It also has the at least equally, if not more important advantage of a thoroughly united and unified foundation and surface, and two courses being of the same class of materials. The advantages are:

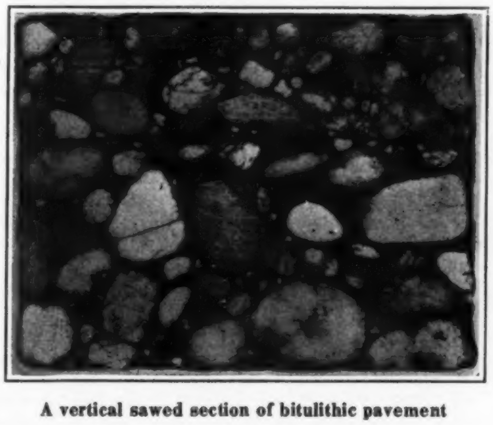
(a) Retarding the tendency of the wearing surface slipping or shifting under traffic, either on the base or through the integral parts of the surface rolling on themselves.

(b) Such a unified foundation and surface also permits the use of a somewhat thinner pavement, both as to surface and foundation, than is equally safe when the foundation and surface are of widely different and non-unified materials as bituminous surface and either crushed stone or Portland cement concrete foundation.

In first cost of surface and foundation the difference depends chiefly on the local relative costs of Portland cement and suitable bituminous cements.

Most of this work has been laid to a total depth of 5 inches, *i. e.*, 3½ inches of compressed bituminous concrete base and 1½ inches of compressed surface, but in some places an additional 1-inch depth of base has been used, making a total depth of 6 inches.

During the past year the laboratory of the Company with which I am associated has done a great deal of work investigating the use of silicate of soda as the cementing material for concrete foundations and finds that, in connection with a substantial waterproof bituminous wearing surface, which is also necessary to secure highest efficiency with Portland cement concrete, it is quite practicable to make high grade concrete foundation in



A vertical sawed section of bitulithic pavement

this way. The question is one of relative prices of Portland cement and silicate of soda and consequent first cost of construction. The silicate of soda concrete has greater resiliency and less rigidity than Portland Cement Concrete and apparently materially lessens, if it does not entirely overcome, the cracking of Portland cement concrete foundation.

In conclusion, may I reiterate that there is no "best" or "most efficient and economical" type of foundation for all conditions. The purpose of this paper has been to outline the most important of the conditions to be given careful consideration in each case.

Sound-Areas of Great Explosions

It is not often that a great explosion occurs near the center of a populous area, and the recent disaster in East London thus offers an opportunity of adding to our knowledge on the transmission of sound-waves by the atmosphere. A brief summary may first be given here of the results obtained in recent investigations. The most remarkable result is the recognition of the fact that there exists sometimes, not always, a zone of silence which separates two detached sound-areas. This zone has been traced in twenty recent explosions (excluding that of Friday, January 19th), two being due to gunfiring, four to explosions of dynamite or gunpowder, and the remainder to volcanic explosions in Japan.

The source of sound is always unsymmetrically placed within the inner sound-area, and nearly always lies on the side facing the outer sound-area. On this side the boundary of the inner area may be as near as 2½ miles, or as distant as 39 miles, from the source. The most important dimension, however, is the radius, or mean radius, of the curve which forms the outer boundary of the zone of silence. It is far from being constant. It may be as low as 50 miles, as with the minute-guns fired at Spithead on February 1st, 1901, or as high as 99 miles, as with the Wiener-Neustadt explosion of 1912.

During the four years 1909-13 eleven explosions of the volcano Asamayama, in central Japan, have given rise to double sound-areas, in most of which the outer area is the larger. The inner area is arranged with a rough approach to symmetry about the ash-precipitation zone. This is usually a long narrow band, the direction of which is determined by that of the higher air-currents into which the smoke-cloud from the volcano rises. The direction of the band is usually towards the east, but varies between northeast and southeast, and it is a significant fact that, as Prof. Omori has pointed out, the center of the outer sound-area is usually on or close to the continuation westwards of the ash-precipitation zone. Of 22 important explosions of the Asamayama from December, 1909, to the end of 1913, Prof. Omori notices that single sound-areas occur just as frequently as double sound-areas. Nine of the former occurred in the six winter months, and ten of the latter in the six summer months. On the theory that the zone of silence is due to the refraction of the sound-rays by winds varying in velocity, and sometimes also in direction, with the altitude, Mr. S. Fujiwhara has shown that, with the normal type of winter weather in Japan, the sound-areas would be single, and with that of summer weather, double.

With regard to the distance to which explosions may be heard, it would be well to separate those in which the sound-areas were single from those in which they were double. Of the first class, the explosion at Avigliana (northern Italy) in 1900 was heard at Lugano, 99 miles distant. The explosion in the same year at Kobe (southern Japan), which probably belongs to this class was heard at 97 miles. Of explosions with double sound-areas, the distances are 90 miles for the Hayle (Cornwall) explosion of 1904, about one hundred and twelve miles for the Förde (Westphalia) explosion of 1903 and the Jungfrau railway explosion of 1908, and 186 miles for the great explosion at Wiener Neustadt in 1912.

Though later accounts may modify some of the dimensions given below, a first analysis of the reports already received shows that the explosion in East London on January 19th belongs to the class with double sound-areas. The inner area is of unusual form, being L-shaped, with the angle near Godalming, the east-and-west limb reaching to Canterbury, and the north-and-south limb to the neighborhood of Northampton. The least distance of the boundary of the inner area from the source of sound is about twelve miles, and the greatest distance 65 miles.

The outer sound-area lies to the north of the other, with its center a few miles west of King's Lynn. Its longer axis (131 miles in length) reaches from the neighborhood of Nottingham to that of Lowestoft, its width being about fifty-five miles. The zone of silence varies in width from 16 miles (near Northampton) to 54 miles, and the distance of its outer boundary from the source is about sixty miles. So far as is known at present, it includes the greater part of Essex and Suffolk, the southern half of the counties of Cambridge and Huntingdon, and the central portion of Northamptonshire. Even if observations should be received afterwards from this area, it is significant that, from the inner sound-area of about 3,500 square miles, I have so far received 250 records in which the time is given, from the outer sound-area of about 5,700 square miles 223 records (including 122 from Norfolk and 56 from Lincolnshire), and from the zone of silence of about 4,500 square miles only one, and that one close to the sea. The greatest distance to which the sound-waves penetrated is about 121 miles.

A remarkable feature about these records is that, though all of them have been sent in reply to my newspaper letters (and therefore sent as it were at random), they are almost as thickly grouped near the boundaries as near the centers of the two areas. There is none of that increasing sparseness of records near the boundary which is so characteristic of earthquake investigations. It would seem as if the boundary were determined, not by the sound-vibrations becoming inaudible, but by the absence of sound-vibrations from the area beyond. It may be of interest to add that, at a large number of places, pheasants showed signs of alarm, as they did during the North Sea battle of January 24th, 1915.—Charles Davison in *Nature*.

Man and the Universe

His True Perspective as Through a Telescope Reversed

By C. M. Kilby

"What a piece of work is man! how noble in reason! how infinite in faculty! in form and moving how express and admirable! in action how like an angel! In apprehension how like a god! the beauty of the world! the paragon of animals! And yet, what is this quintessence of dust?"

Measured by man's standards man is a mighty being, a colossus, the lord and ruler of the world, and in our younger days man seemed to be almost the lord of the universe, or at least the universe seemed to be made for him. Fortunately, as we grow older this magnification decreases until finally we see man in his true perspective—as through a telescope reversed. Then he is known to be only an infinitesimal in infinite space. He is but a speck upon a ball 8,000 miles in diameter, rotating on its axis once in 24 hours, and revolving around the Sun in about 365 days at the rate of 18.5 miles per second. Around this Sun, which is one of the smaller and cooler stars and which appears large because it is only 93,000,000 miles from us, revolve other planets—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune, in order, whose distances from it range from 36 to 2,800 million miles.

Along with this solar system of Sun, planets, meteors and comets, we speed through space at twleve miles per second, not knowing whither we go nor why. Other suns, or stars, doubtless have their planetary systems also, and all, according to our observations, are hastening through space. The unaided eye sees but 6,000 of these stars, but the telescope reveals 100,000,000. The nearest one to us is 25,000,000,000,000 (25 trillion) miles distant and heaven only knows how far is the farthest. Though light travels at a rate of 186,000 miles per second, it takes about four and a half years for light to come to us from the nearest star, αCentauri, and fifty years to come from the Pole star. Therefore some of the stars we are now seeing may have been blotted out centuries ago.

Our only visitors are meteors and comets. Several hundred meteorites have actually reached the Earth and been found. They are the remnants of former worlds that tell us that those worlds were composed of the same materials as our earth. Most of these intended visitors are burnt to powder by friction when they strike our atmosphere, and become but dust of our Earth. Some that contain occluded gas burst with explosive violence and furnish us beautiful pyrotechnics. All are small and weigh less than 500 pounds.

The comets are more distinguished visitors, but are light, airy nothings with electric tails. In passing through our solar system their orbits and motions are changed by the influence of the Sun and the planets—especially Jupiter—and thus are captured for trespassing. Many of the phenomena accompanying them are optical and electrical and change as they continue on their courses.

Of all this how much does man control? Is he monarch of all he surveys? He has no voice in their motions, no power to change the course of even one meteor. He is but an onlooker, a passenger through space without chart or compass, or even steering gear. Around and 'round he goes "on the whirligig of time circling with the seasons," which cover him with their snows, bite him with their frosts, and scorch him with summer suns: and he can not lift a hand to stay them.

Though man is but a speck compared to his habitat, the Earth itself is not so large. When we consider some measurements it seems not only large but immense. For instance, its surface contains 200,000,000 square miles, its volume is 260,000,000,000 (260 billion) cubic miles, and its mass is 6,600,000,000,000,000,000,000 (6,600 million million millions) tons. There are 52,000,000 square miles of land and 145,000,000 square miles of water, and living here are 1,500,000,000 persons. These numbers are large and hence our magnified idea of the size of our planet. But a square mile, a cubic mile, and a ton are all small quantities, and hence these large numbers. If it were said that a year consists of 31,536,000 seconds, one might get the idea that a year is an aeon. And so numbers sometimes fool us.

Though the earth is 25,000 miles in circumference it can be circled in a few days. At the new moderate speed of 60 miles per hour it would require but 17 days. Its curvature shows a drop of 8 inches in 1 mile and 64 inches in 2 miles. The lower 600 feet of a mountain only 30 miles distant are below the horizon. And so it seems that our Earth is indeed a ball, and a small one at that. Its surface is nearly smooth, as its highest mountain, Everest, rises less than six miles above sea-level, and the ocean bed is about the same distance below.

Man on his island home is a creature of circumstances. If the earth's temperature were to rise 40 or 50 degrees above, or drop as much below, the present range, he would pass away and the place thereof would know him no more. Or, if the Sun's temperature were to fall as much as 14 deg. Fahr., a glacial period would occur and refrigerate us all. A slight change in the relative amounts of oxygen and nitrogen constituting our atmosphere would end our days. If the water were removed our bodies, which are 90 per cent water, would soon wither away.

Why man was placed here and whither he goes—who can tell? In spite of his insignificance and impotence, he has gazed into space and explored the starry regions. He has discovered many mysteries and solved many riddles, but the First Cause and the final consummation remain unrevealed to his intellect. And so, "there is a door to which he finds no key, there is a veil through which he can not see."

But he has seen and discovered many things. With his science he has dispelled the idea that the stars and planets are divinities, that they are candles periodically lit, and shown that they are simply masses of matter. He knows that the Earth is not flat and that it is supported neither by a tortoise nor by Atlas. Nor is the earth the center of the universe, nor even the center of one of the numberless systems. With the aid of his chemical balance and reagents he can say that the Earth's crust contains 47 per cent oxygen, 28 per cent silicon, 8 per cent aluminium, 4 per cent iron, 0.17 per cent hydrogen and 0.12 per cent carbon. With his barometer he can tell us that the atmosphere extends but seventy miles above the Earth's surface. He can point his telescope to the sister planets, see, and photograph their surface marking; with his spectrometer he can tell what elemental substances constitute the Sun and stars; and with his bolometer he can tell you that the temperature of the Sun is 12,000 deg. Fahr. and that the Moon is icy cold. With his Coulomb's balance he can weigh the Earth, and with the aid of his scientific laws determine the mass of the planets and the Moon, and predict eclipses. He has told us that the solar system was formerly a nebula, which by gravitation and cooling formed the Sun and planets. He has pointed out 10,000 nebulæ, which slowly, but surely, are condensing to form other solar systems. He has discovered the cosmic process, evolution, a cyclic process without beginning and without end, progressive and continuous. From internal evidence he finds that the Earth has reached the age of some 60,000,000 years. Though still cooling and contracting its end is in the dim and distant future. Within its surface much heat is stored, for as we dig down its temperature increases 1 deg. Fahr. for even seventy feet. The Sun, a mass 880,000 miles in diameter, has cooled more slowly an its temperature is yet 12,000 deg. Fahr. Through calculations it is known that the Sun's heat is not due merely to cooling, for if it were its temperature would not long remain constant. As it cools, it contracts; as it contracts, its temperature is raised; and thus its heat is maintained. Another factor in this maintenance is the wonderful metal radium, which undoubtedly exists in the Sun. This metal is a heat factory in itself.

Not only has he delved into the past, but he has dipped into the future and predicted discoveries of other worlds. The prediction and discovery of Neptune, the farthest known planet, is evidence of his ability and acumen.

Man's inquiries have not been limited to the inanimate matter of the universe. For centuries he has wondered whether worlds are inhabited. It was formerly thought that all of the planets, stars, Moon and Sun were inhabited, but now we know that this cannot be unless their residents are far different from us.

In ancient times it was said that the heavenly bodies were round because the circle is the perfect figure. It was also thought that their motions and conditions were permanently fixed because established by a perfect creator. Though the motions and forces of the Sun, Earth and Moon are finely balanced, we know now that sooner or later their equilibrium will be destroyed and that the Earth will be ground to pieces by the Moon or fall into the Sun to be destroyed by fire. Whether the Earth will be refrigerated and depopulated along before such a cataclysm occurs, man cannot yet tell.

As the solar system is speeding toward the constellation Hercules, perhaps to join the cluster of 6,000 stars observable there, the avoidance of a collision with other system seems impossible. Such a collision would start another cycle in the evolutionary process. Thus one cycle follows another, but all are in the same progressive march through enternity. Was there a beginning? Man can find no evidence of it; nor can he find any promise of an end. The present stage is but a phase of the endless cosmic cycle: condensation—collision—heating—nebulæ; then condensation, collision, etc., again. The creator has not finished his work—and never will. "He is ever present, ever-working throughout the universe—an Infinite and Eternal Energy. And

> "When you and I behind the veil are past,
> Oh, but the long, long while the world shall last,
> Which of our coming and departure heeds
> As the sea's self should heed a pebble cast."

Man has not only made measurements and calculations of things seen, but has also launched his mind upon the sea of infinity to explore its unknown shores and answer the riddles that he meets. He does not balk at the question, "Is the universe infinite?" though he knows that he can not conceive of infinite space because the idea is beyond the power of his imagination. But this fact does not prevent an answer to the question. As Spencer has said, "Conceivability or nonconceivability is never proof." Man employs his reason and argues that since everything occupies space, space can be limited only by space. Therefore, it is self-limited only, and therefore endless and infinite. Again who would deny that 1.0/3 gives an endless result, an infinity of 3's? Yet imagination can not cope with them. Thus reason attests an infinity though imagination can not reach it. Again, reason suggests that time is infinite—without beginning and without end—but mind can not grasp the idea.

So man, the quintessence of dust, is but a mote in an infinity of infinities. Though his "dim horizon is bounded by a span," he gazes intently at the passing show that comes within his ken—an onlooker who can control nothing—one of the "magic shadow shapes that come and go 'round with the sun-illumined lantern held in midnight by the master of the show; one of the helpless pieces of the game. He plays upon this checker-board of nights and days, hither and thither moves, and checks and slays, and one by one back in the closet lays."

Through infinite space he whirls in complex spiral motion at thirty miles per second, speeding on and on until his days are ended. Like the poor player upon the stage he struts and frets until his part is done. He is but a "flower of the field which to-day is and to-morrow is no more." "He dieth and wasteth away: yea man giveth up the ghost, and where is he?"—*Popular Astronomy.*

Benzol Recovery and Rectification

The authors estimate that the present production of benzol is about 38,000,000 gallons per annum and that if all the benzol was recovered from the coal carbonized at gas works, the production would be approximately 60,000,000 gallons per annum. The oil used for absorbing benzol is generally coal-tar creosote, but both anthracene oil and blast-furnace creosote are also used. The oil should be as free as possible from naphthalene and water, and the gas should be completely freed from ammonia before entering the benzol absorbing plant. Approximately 100 gallons of absorbing oil must be passed through the scrubbers for every ton of coal. The benzolized creosote oil leaving the scrubbers contains about 3 per cent of benzol and this is recovered by distillation, either by direct fire or by steam, as "65 per cent benzol," *i.e.*, benzol which yields 65 per cent of distillate at 120 deg C., when distilled in a retort, the bulb of the thermometer being immersed in the liquid. Steam is preferable where large quantities of oil are to be dealt with, and in a recent test 66 pounds of steam at 100 pound per square inch-pressure was required for every 100 gallons of benzolized creosote. The 65 per cent benzol is rectified in the usual way after washing to remove impurities.—P. D. Walmsley and H. A. Marfey, Manchester District Inst. Gas Eng. From a note in the *Journal of the Society of Chemical Industry.*

Development and Toning of Motion Picture Films*

By Charles I. Reid

CINEMATOGRAPHIC films, both negative and positive, are coated with emulsions to meet the special requirements of this branch of photography, and therefore need special chemical treatment in order to obtain the very finest results. The requirements for a good motion picture negative are fine definition, perfect gradation and evenness of density. The latter can only be obtained with a developer that is perfectly even in its action on the exposed film, which is not always the case with the developers used for plates and roll films. Pyro and hydrochinon are the most widely used developing agents for this work. The former, on account of its poor keeping qualities and the frequency of stains, is not used to any great extent, while the latter is widely used both for the development of negatives and positives. Hydrochinon was formerly used in combination with metol, but since the visible supply of the latter chemical has been exhausted motion picture producers have been compelled to adopt a new formula, using only hydrochinon as a developing agent. Hydrochinon has the reputation of being a developer which gives great contrasts, and it is not generally known that, with the proper manipulation, it is capable of great variation in results. With proper care one may obtain results which compare favorably with those obtained from any other developing agent, or combination of these agents, and these results are almost indistinguishable in the finished product from those obtained by other means. The following formula is in use by some of the largest motion picture factories, and is calculated for both negatives and positives. The chemicals used in mixing this formula should be of the highest technical purity, for while it is always important that the chemicals used in photography should be of standard purity, it is doubly important with hydrochinon, which is very sensitive to a variation in the sodas with which it is mixed. Dissolve chemicals in order named.

Water	10 gallons
Hydrochinon	13 ounces
Sodium sulphite—dry	4 pounds
Sodium carbonate—dry	4 pounds
Potassium bromide	3 ounces

As the temperature of the developing solution has a very great effect in the contrast and density of the silver deposit in developing with hydrochinon, it is very essential for the attainment of the proper gradation that the developer should be kept at a temperature between 65 and 68 deg. Fahr. As the prevention of stain is very important, it is well to rinse the film, after development, in a short stop composed of

Water	10 gallons
Acetic acid, No. 8	32 ounces

after which the film is transferred to an acid fixing bath. After fixing, the films are washed in running water for an hour, and then placed in a well-ventilated, dustless place to dry. Drying can be accomplished on the frame used for developing, although a drying drum will prevent the kinks that result when the film is dried on a square frame. After the black and white positive film is finished, it is still possible to improve many of the scenes of a photo-play or commercial motion picture by the judicious use of toning and tinting solutions.

It is opportune here to get a clear idea of the difference between the terms toning and tinting, which might otherwise confuse one who has perhaps never given any thought to the subject. Toning is the term applied to a chemical action such that the color of the silver deposit forming the image is changed, and therefore when we tone a picture we change the color of the shadows or dark parts of the picture, *the highlights remaining unchanged.* Tinting, on the other hand, is the term applied to the process of staining the highlights, the shadows retaining their original black color. This latter process, tinting, is the more simple of the two, and is often used to tint the titles of a film, as well as to give the effects of different forms of lighting. For instance, fire scenes, or scenes supposedly taken near a fire, are usually tinted a bright red, the same color in various shades also being used for sunsets. Night and snow scenes are often tinted blue, the same color with perhaps a mixture of green also being used for water scenes. Toning is a somewhat more complicated, although not very difficult, process, and one that is capable of giving very realistic effects. Scenes containing trees or shrubbery are very effective when toned to a green color, while portraits and other scenes of a photo-play staged indoors are often toned sepia.

*From *American Photography.*

The formulas used for toning motion picture films have been closely guarded by the large producing firms, who in most cases worked out their own formulas. The hypo-alum and redeveloping formulas used for sepia toning of paper prints cannot be used for motion picture films, both on account of difference in the emulsions, and the different shade of color required for projection purposes. Toning can be accomplished by two different methods, by the old process employing salts of copper and uranium, or with the special toning colors supplied by the manufacturers of film. After using copper and uranium for years, the writer has found the special preparations so superior, both as to the colors obtained and the permanency of both solutions and results, that it seems hardly necessary to give any further attention to the somewhat uncertain copper and uranium process. The toning process requires three separate solutions, the bleaching bath, the toning solution, and the clearing bath. The pictures are first of all completely bleached in the bleaching or ferricyanide solution. The film is then rinsed briefly and immersed in the toning bath for from two to six minutes, according to the color used. The following formulas have been found to give very desirable colors in projection, the final test of all motion picture formulas:

BLEACHING SOLUTION.

Potassium ferricyanide	350 grains
Potassium iodide	700 grains
Water	2 gallons

ACID BATH.

Water	2 gallons
Hydrochloric acid	7 drachms

The above formulas are used with all the different toning solutions following:

TONING SOLUTION FOR PURE GREEN RESULTS.

Blue green toning color	700 grains
Citric acid	1,050 grains
Water	2 gallons

YELLOWISH GREEN RESULTS.

Green toning color	810 grains
Citric acid	220 grains
Water	2 gallons

PURE SEPIA IN PROJECTION.

Yellow toning color	440 grains
Acetic acid, commercial	4½ ounces
Water	2 gallons

PURE RED.

Red toning color	615 grains
Citric acid	220 grains
Water	2 gallons

After toning to the desired depth, the film is immersed in the acid or clearing bath until the highlights are clear of all color, after which the film is washed in running water for one half hour, and placed in a dustless, well-ventilated place to dry. These same toning formulas can also be used for lantern slide plates, giving very fine effects with subjects that might otherwise be flat and uninteresting.

The process of tinting motion picture films is comparatively simple, but nevertheless allows of great variation in results. The time of immersion or the strength of the solution can be regulated so as to obtain any depth of color, from the faintest tint to the most intense shade—and in between these two extremes the operator can find the shade most suited to the subject in hand. The beginner need have no anxiety over the prospect of spoiling the first attempt, as the color can be entirely removed by the simple method of soaking the film in water for about thirty minutes, after which the tinting process can be repeated. It is preferable to do the tinting after the film has dried for the first time, as otherwise, owing to the presence of an uncertain amount of water in the emulsion, the tinting is likely to be somewhat uneven, which is a condition to be avoided by all means. For this latter reason, also, the solutions should be very thoroughly mixed before using. The formulas given below will give the tints that are most desirable in the average number of cases:

BRILLIANT RED.

Water	2 gallons
Aniline red Z	150 grains
Citric acid	120 grains

PURE RED.

Water	2 gallons
Aniline red R	220 grains
Citric acid	150 grains

PURE PINK.

Water	2 gallons
Aniline red V	90 grains
Citric acid	240 grains

PURE ORANGE.

Water	2 gallons
Aniline orange	180 grains
Citric acid	90 grains

BRILLIANT YELLOW.

Water	2 gallons
Aniline yellow	210 grains
Citric acid	120 grains

LIGHT BLUE.

Water	2 gallons
Aniline blue	120 grains
Citric acid	120 grains

DARK BLUE.

Water	2 gallons
Aniline blue R	180 grains
Citric acid	60 grains

TRUE GREEN.

Water	2 gallons
Film blue	90 grains
Film yellow	120 grains
Citric acid	120 grains

After tinting, the film is rinsed in cold water and placed in a well-ventilated place to dry. The drying should take place as quickly as possible, and if the drying is done on the developing frames, they should be turned occasionally while drying, in order to prevent any streaks or unevenness in the finished result. The ideal positive for tinting is one that is not too dark. A film to be tinted should be a shade lighter than one to be projected in black and white only, unless the aim is to give the effect of a night scene. These tinting solutions will keep almost indefinitely, but should be protected from dust and light as much as possible while not in use. These same formulas can be used with good results for tinting lantern slides and paper prints.

War-Time Inventions in England

THERE surely never can have been such an age as the present of inventions and inventors, and for this state of affairs the war is undoubtedly responsible. In the past inventors, it must be admitted, were all too frequently looked upon as a nuisance by the majority of people, not even excepting engineers. In times like the present, however, inventors cannot be ignored, for it may be that even an unpromising idea has in it possibilities of the utmost moment from the point of view of furthering our victory on sea or in the field of battle.

The Government have shown their appreciation of this fact by setting up in London, and making readily accessible to all inventors, three bodies of experts charged with the work of examining and reporting upon inventions likely to assist the war. These are the Munitions Inventions Department, the Admiralty Board of Inventions and Résearch, and the Trench Warfare Research Department. All of these are at the present moment paying the closest attention to a large number of most promising inventions which, but for the Government's action in this matter, might not have been able to receive consideration.

This experiment on behalf of the Government in the matter of war inventions is being watched with the closest interest by our Allies. Russia has gone even a a step farther than this country, in that a National Congress was held last month with a view to the general organization of invention work in Russia.

Inventors in this country should know that they are no longer allowed to keep to themselves particulars of any inventions that may lead to the more efficient or increased production of war material. By a recent addition to the regulations under the Defence of the Realm Act an inventor is obliged, if required by any duly authorized person, to communicate all such particulars as may be in his possession "of any invention, or process, or method of manufacture, or of any article manufactured or proposed to be manufactured, and to furnish drawings, models, or plans thereof, and to explain and demonstrate the same to such person, in all or any of its uses and workings." Any secrets that may be divulged under the terms of the new regulation may be regarded as specially safeguarded, and to divulge in this way information with regard to inventions will not prejudice any right of the inventor subsequently to apply for a patent for the invention.—*The London Daily Telegraph.*

Gravity*

An Account of Observations Made in Canada

By F. A. McDiarmid, Dominion Observatory, Ottawa, Canada

Gravitation is an attractive force which exists between any body and the earth in virtue of which they tend to move toward one another. It is a matter of common experience that all unsupported bodies near the surface of the earth fall to the ground, the direction of their motion being toward the center of the earth. This phenomenon is due to the attractive force just defined as gravitation. The motion of the earth and other planets around the Sun may be explained on the same basis. The mode of action of this force is given in the following generalization, first implicity given by Newton and known as Newton's *Law of Gravitation*. "Every particle of matter in the universe attracts every other particle with a force whose direction is that of the straight line joining their centers, and whose magnitude is directly proportional as the product of their masses, and inversely proportional as the square of their mutual distances."

Previous to Newton's investigations Kepler, by a truly prodigious amount of work, had deduced from the observations of Tycho Brahe the following kinematical laws of planetary motion: (1) The path of each planet is an ellipse, one focus of which is occupied by the Sun; (2) The radius vector, i. e., the straight line which joins the center of the Sun to that of the planet, of each planet describes equal areas in equal times; (3) The square of the periodic times, i. e., the time during which a planet makes one complete revolution about the sun, of each planet is proportional to the cube of the major axis of the ellipse. From the second of these deductions Newton showed that if the sun attracts the earth, or other planet, the direction of this attractive force must be in the line joining their centers; from the first and third he proved that its intensity must be inversely proportional to the square of their distance, so that at double the distance the intensity of the attracion would be one fourth, etc. Lastly, the proof that the attraction is proportional to the product of the masses is found in the fact that the weight of any body is under all circumstances proportional to its mass. To test the truth of his deductions Newton studied the motion of the Moon around the Earth, and found that this satellite is retained in its orbit by an attraction which is exactly the same as that which causes a body near the earth's surface to fall with an acceleration of (about) 32.2 feet per second per second.

It must, however, be remembered that Kepler's laws are only approximately true, owing to the attraction of one planet on another interfering with what might be called the ideal state of things, and thus producing those small superposed motions of a planet which astronomers call perturbations. But it is just in this that the confirmatory proofs of the law of gravitation are found; for not only are all these perturbations explained by this means, but they have been discovered and measured by it.

The action of gravity is independent of the nature of matter, thus differing from magnetic attraction which is only found in a restricted class of bodies. At the same time the manner in which magnetic and also electric attraction depends upon distance is the same as gravitation. The force of gravitation is not affected by the presence of other matter; in other words, the weight of a body is the sum of the weights of its parts.

The intensity of gravity at the earth's surface is measured by the acceleration of a body falling freely under its influence, and is usually denoted by g. It varies slightly with the latitude, and the distance above sea level, and the density and nature of the topography surrounding the station of observation. Gravity increases from the equator to the pole. This is due to two causes; first, owing to the ellipsoidal shape of the earth the force of gravitation is 1/590 greater at the pole than at the equator, and second, on account of the centrifugal force of the earth's axial rotation, bodies at the equator are 1/289 lighter than at the pole, where this axial equator has no effect; or the combined effects is to make a body 1/193 lighter at the equator than at the pole. A body will therefore decrease in weight as it is carried from the pole toward the equator. The number of swings a pendulum makes in a day or hour depends upon the attraction of the earth. The further we are from the center of the earth the less will be this attractive force, and the fewer the swings of the simple pendulum in a given period of time. If a clock which keeps accurate time in latitude fifty degrees north be carried to the equator it will lose time.

The method employed to determine the force of gravity is that of the pendulum. If l is the length of the simple pendulum and t the period in seconds (the time between the passages of the lowest point of the pendulum by the middle point of the swing), and g the acceleration due to gravity, the time of a small oscillation *in vacuo* is expressed by the formula.

$$t = \pi\sqrt{\frac{l}{g}}\left(1 + \frac{a^2}{16}\right)$$

where a is the maximum inclination of the pendulum rod to the vertical and the unit of time is one second. With infinitesimal vibrations $t = \pi\sqrt{l/g}$. In order to obtain g, the value of the force of gravity, we must determine t, the time of one vibration, and l, the length of the pendulum. The time of one vibration, or the period of the pendulum, can be determined to a very fine degree of exactness, the units in the ten-millionth part of a second; but the length of the pendulum is very difficult to determine. So difficult is the problem of determining the absolute length of the pendulum that the method has been abandoned, and the relative method is used entirely. This method depends on comparing the periods of the same pendulum as determined at two stations, one of which is used as a base station. If the periods of the pendulum at the two stations be t and t' seconds respectively, and g and g' the values of gravity at the two stations, then there is obtained the relation

$$t/t' = \sqrt{g'/g}; \text{ or } g' : g = t^2 : t'^2$$

or, the value of gravity at the two stations varies inversely as the squares of the periods of the pendulum, provided l, the length of the pendulum, remains constant. This method is now used by all the geodetic and geophysical surveys of the world. All determinations are based on some one point which, of course, has to be determined absolutely. The values of gravity at the different stations in the United States are all based on the value determined for the pier in the basement of the Coast and Geodetic Survey building at Washington. The value of gravity for this pier was obtained by comparisons of the periods of pendulums at Washington and Potsdam, Germany, by Mr. Putnam of the Coast and Geodetic Survey, the absolute value of gravity at Potsdam having been determined previously.

Canada is a new field for gravity research. In 1902 the Department of the Interior purchased a set of pendulums and the auxiliary apparatus, and Dr. Otto Klotz, Assistant Chief Astronomer, after standardizing the pendulums at Washington, observed at Ottawa, Toronto and Montreal, and in 1905 Prof. Louis B. Stewart, of the University of Toronto, observed at North West River, Labrador. From 1905 till 1914 gravity observations were abandoned in Canada, but during the winter of 1913 and 1914 preparations were made for a systematic gravity survey of Canada. In order to have some repairs made to the instruments and also to restandardize the pendulums the writer was directed to proceed to Washington, where, on the pier in the basement of the Coast and Geodetic Survey building, the periods of the three pendulums of the Canadian set were determined. Observations were then made on the pier in the basement of the Dominion Observatory and thus Canada was connected to the gravity survey of the world. In order to check the observations and to strengthen the value of the result a second set of observations was made both at Washington and Ottawa. The mean of the two determinations was accepted as the observed value of the force of gravity for Ottawa. The observed value for Washington is 980.112 dynes, and the value for Ottawa, as determined by the comparison of the pendulum periods at Washington and Ottawa, is 980.615 dynes. All stations in Canada are based on this value at the Dominion Observatory.

The Canadian pendulum outfit was patterned after the one constructed for the United States Coast and Geodetic Survey. In 1891, Prof. Mendenhall, at that time superintendent of the Coast and Geodetic Survey, had constructed a half-seconds pendulum apparatus which has been in use ever since; and the Canadian pendulums are nearly exactly similar. The characteristic features are, three invariable non-reversible pendulums; an air-tight receiver in which the atmospheric pressure is under control; a flash apparatus for noting coincidences between the oscillations of the pendulums and the two-seconds beat of the sidereal chronometer used in the observing; and a dummy or temperature thermometer.

Pendulums.—There are three pendulums in a set, and the period of each is determined separately and independently. The pendulums are made of an alloy of aluminium 10 per cent and copper 90 per cent, a composition which experiment proved to have a very high resistance to corrosion; they are highly polished but not lacquered. Each weighs about 1,200 grammes, and is about 248 millimeters in length from the center of the bob to the agate plane. The stem and bob are designed to have as little resistance to the air as possible. The bob is solid, and is 9 centimeters in diameter and 4.5 centimeters thick at the center. The stem of the pendulum is rectangular in section, 4 by 14 millimeters, with rounded edges, and is rigidly fastened to the head and the bob. The pendulums have an agate plane set in the head which rests on an agate knife edge on which they are swung. This knife edge is formed by carefully ground planes meeting at an angle of 130 degrees, thus insuring great permanency.

A small rectangular mirror is set in the side of the pendulum head. This requires very careful adjustment, so that the image of the slit in the flash apparatus, described later, will be reflected into the same portion of the field of the observing telescope, when the latter is properly placed, and in line with the image of the fixed similar mirror on the plate carrying the knife edge.

The pendulums are carried to and from the box in which they are kept by a double-jointed handle which has leather lined hooks fitting under pivots on each side of the head. The pendulum should never come in contact with the hand; it is brushed before every observation with a very fine camel's hair brush. When placed in the receiver the pendulum is first suspended upon two pivots carried on the end of a lever, which pivots fit into corresponding sockets in the head of the pendulum. This lever is moved by a large screw which passes through the wall of the receiver so that the pendulum may be gently lowered and raised without injury to the knife edge, which could not so safely or readily be done directly by hand.

The temperature of the swinging pendulum is obtained by means of a dummy, similar to the others in material and dimensions, save it has no mirrors, and is so supported in the receiver that it cannot oscillate. It has mounted on its side a thermometer whose bulb is buried in the stem near the bob, and packed with the alloy filings, so as to obtain the temperature of the swinging pendulum.

Receiver.—The body of the receiver is a heavy brass casting, with walls seven millimeters thick, and of inside dimensions seventeen centimeters square at the top, twenty-one by twenty-eight centimeters at the bottom, and thirty-eight centimeters high. The cover makes an air-tight joint when a little lard, tallow or vaseline is applied to the contact surfaces. A portion of the main casting forms a solid shelf, but having openings in it through which the pendulum, dummy and lever hang. This shelf carries on one side a plate on which the dummy pendulum is supported, and on the other the plate carrying the knife-edge on which the pendulum swings. This latter plate is supported on three points and firmly screwed to the shelf. To it is attached the adjustable fixed mirror which is so adjusted that the images of the slit, as seen in the observing telescope, reflected from this mirror, and from that on the pendulum when hanging freely at rest, will appear in the same horizontal line and will slightly overlap one another.

There is a scale below the pendulum and a small telescope mounted on the side of the receiver for reading the arc of oscillation. The receiver is supported on three heavy foot-screws resting on three heavy circular foot-plates which are cemented to the pier with plaster of Paris. The case is leveled in the plane of oscillation by the pendulum itself as shown by the reading of the tip of the pendulum on the scale beneath. In the transverse plane it is leveled by a small level mounted on a short pendulum which may be reversed on the knife edge. On the sides of the receiver are two levels to assist in leveling the case. Within the receiver is a short arm for setting the pendulums in motion. The point of this arm is covered with leather,

*The Journal of the Royal Astronomical Society of Canada.

and is worked from the outside. A mercury manometer is hung within the receiver, and by means of a portable air-pump the air pressure can be reduced to any amount required, generally to about fifty millimeters of mercury. Three windows are provided in the case for observing the mirrors—arc scale, dummy thermometer and manometer.

Flash Apparatus.—The flash apparatus consists of a light metal box, mounted on a brass stand having both vertical and azimuthal movements and clamps, and carries with it an ordinary observing telescope, which may be focused for objects within a few feet. The object of the flash apparatus is to observe coincidences between the swinging pendulum and the chronometer. The box contains an electro-magnet, whose coils are connected with the chronometer circuit, and whose armature carries an arm which moves two shutters. By an ingenious device a flash of light is emitted from the box when the circuit is broken, but not when it is closed. A small oil lamp attached to one side of the box furnishes the light for the flash.

The details of the apparatus are too complicated to be described in full. It will be sufficient to say that the flash, as seen in the telescope, appears to travel by successive jumps up the field of view and then down, and by observing this motion the time of a single oscillation of the pendulum can be determined with great accuracy.

Use of Apparatus.—The pendulum apparatus was always mounted in some place where the changes of temperature would be a minimum, and a cellar with a good dry concrete floor generally supplied this requirement. Three stones about five inches thick were used as the pier for the receiver. They were cemented to the concrete floor of the cellar with plaster of Paris and the receiver was placed on them. The change of temperature of these pendulum rooms rarely exceeded two Centigrade degrees during the three days spent at a station. Before commencing observations care must always be taken to allow the pendulums and the receiver to reach the temperature of the observing room. If the temperature of the observing room is constant, thermometer readings at the beginning and the end of a swing will be sufficient, but if the temperature is fluctuating, then the thermometer must be read frequently. In order to keep the temperature constant it is well to close all windows and doors. Black cotton is used for darkening windows and cutting off extraneous light.

After the instrument has been mounted and adjusted, and the pressure inside the receiver reduced to nearly fifty millimeters, the pendulum is set swinging through an arc of about five millimeters amplitude; and the observer by means of a switch turns either of the observing chronometers on the flash apparatus and notes the coincidences through the telescope. In timing coincidences a hack chronometer, placed on the table near the observer, is used. A complete set of coincidences consists of two up and one down, or two down and one up. Readings are taken with both chronometers on the flash apparatus, the object of the two being to check the observations. The hack chronometer is always compared with the observing chronometers at the end of each set of coincidences. Readings of arc, thermometer and manometer are made and recorded. After approximately eight hours the readings are again repeated. This completes a swing of the pendulum, which then is stopped and restarted and the readings again repeated. Each of the three pendulums is swung in three consecutive eight-hour periods, and at the beginning of the swings the errors of the observing chronometers are determined either by star observations or by comparison with some standard sidereal clock whose rate is well determined. Also at the end of the third swing of each pendulum the errors of the observing chronometers are determined by either of the above methods. The advantage in determining the errors of the chronometers from comparisons with a standard clock rather than from star observations, is in the fact that the observer is not dependent on clear skies to obtain his clock error. It is believed that by swinging the pendulums continuously between time determinations, the effect of diurnal irregularities of rate are entirely eliminated, as it will not be by any other method, and this has been strikingly shown in the Canadian observations of the summers of 1914 and 1915. The average errors in the periods of the pendulums at the different stations is less than 0ˢ.0000001, and the maximum error is about 0ˢ.0000004. The chronometers were rated by comparison with the standard sidereal clock of the Dominion Observatory. Signals were sent over the telegraph line and recorded at the observing station on a chronograph sheet, on which were also the records of the two observing chronometers.

Below follows a set of observations:

Station: Cochrane. Date: July 31st, 1914.

PENDULUM 1, SWING 1.

Bond No. 519.		Dent No. 52866.	
	"19"		"26"
D 13h. 48m. 13s.		D 13h. 50m. 07s.	
	3m. 17s.		3m. 17s.
U 13 51 30		U 13 53 24	
	3 13		3 16
D 13 54 43		D 13 56 40	
	Mean 3 15		Mean 3 16.5

Arc.	Pressure.	Temperature.
mm.	mm.	
2.6	23.0	
3.0	25.0	17°.15
5.6	48.0	

	"38"		"45"
D 21h. 11m. 06s.		D 21h. 11m. 55s.	
	3m. 14s.		3m. 16s.
U 21 14 20		U 21 15 11	
	3 15		3 12
D 21 17 35		D 21 18 23	
	Mean 3 14.5		Mean 3 14

Arc.	Pressure.	Temperature.
mm.	mm.	
1.2	29.0	
0.7	27.0	17°.25
1.9	56.0	

Note.—The figures in quotation marks, as "19" above, are the seconds of the hack chronometer at the even minutes of the observing chronometers.

Reduction of Observations.—From the coincidence interval (i. e., the mean period between an "up" coincidence and a "down" coincidence) is derived the periodic time of the pendulum uncorrected for arc, pressure, temperature, rate and flexure. The reduction must be made to infinitely small arc, to standard pressure and temperature; a correction for rate of observing chronometers and for the flexure of the pendulum case must be applied. The standard pressure is 60 millimeters of mercury, and the standard temperature is 15 deg. Cent. These standards were closely realized in each case and the consequent corrections were small.

The arc correction is given by the following formula:

$$A = \frac{PM.\sin(\phi + \phi')\sin(\phi - \phi')}{32\,(\log\sin\phi - \log\sin\phi')}$$

where P is the period of the pendulum in seconds, ϕ is the initial semi-arc, ϕ' is the final semi-arc, and A is the amount to be subtracted from the period to reduce to infinitely small arc.

The temperature correction is (15 degrees — T) (0ˢ.00000419), where T is the observed temperature in degrees Centigrade.

The pressure correction takes the form of

$$C = k\,[60 - Pr./(1 + 0.00367T)]$$

where C is the correction in seconds (to be subtracted if observed density is above the standard and added if below the standard), k is the pressure coefficient, or variation in period for change of one millimeter in pressure (at 0 deg. Cent.), $Pr.$ is the observed pressure in millimeters of mercury, and T is the mean temperature in degrees Centigrade. The value of k for the Canadian instruments is 0ˢ.000000101.

The rate correction is given by the formula,

$$D = 0^s.00001157RP,$$

where D is the correction to period (to be subtracted if the chronometer is gaining and added if losing), R is the daily rate of the chronometer in seconds, and P is the period of the pendulum in seconds.

The horizontal component of the force acting on the knife edge through the swinging pendulum causes the support to move in unison with the pendulum, and therefore affects the period of the oscillation. This movement is called the flexure of the pendulum support. The movement or displacement is an exceedingly small quantity, and Mr. W. H. Burger, of the United States Coast and Geodetic Survey, first used the interferometer to measure this movement.

The principle of the interferometer is shown in the accompanying diagram (Fig. 1). The beam from the source of light (*) with its rays made parallel by a lens L, strikes the rear or second surface of the plate S, and separates, part of it being reflected to the plane mirror P, returns exactly on its own path through S, and then through C to T where it is examined by a telescope T. The other part goes through the plate S, passes through the plate C, and is reflected by the mirror M, returns on its own path through C to the plate S, where it is reflected so as to unite with the first ray as to produce interference. The result is a series of bands in the form of a grating, as shown in Fig. 2, the dark band being produced when the two wave trains differ by one half a wave-length of light, and the light bands when they are in the same phase.

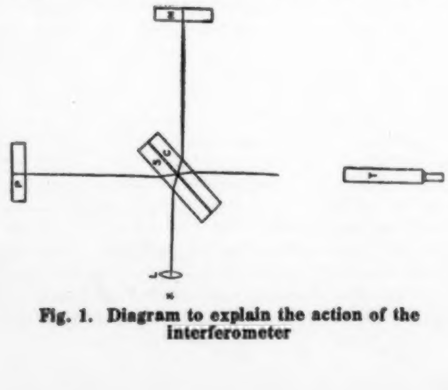


Fig. 1. Diagram to explain the action of the interferometer

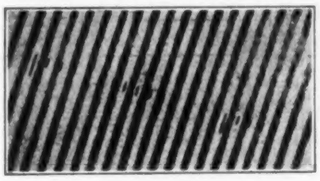


Fig. 2. Fringes and scale

One mirror is attached to the pendulum receiver and the remainder of the interferometer is mounted on a support entirely independent of the pendulum receiver. Any movement of the pendulum receiver will produce a shift or displacement of the fringes in the interferometer. Since the pendulum makes one complete swing in one-half a second, the shift of fringes will occur as a half-second shift across the field. This movement is a measure of the amount of flexure in the pendulum case caused by the oscillation of the pendulum.

The method employed to determine the flexure at the pendulum stations was to observe the width of a fringe in terms of a division of the scale in the telescope, and then observe the amount of the shift or displacement of the fringe band in terms of the scale divisions. The second quantity divided by the first will give the shift of the fringes in terms of their width. The light used is monochromatic, easily produced by the use of sodium chloride and an alcohol flame.

If the fringes shift, or are displaced one fringe-width due to the motion of the pendulum, it is easily seen that the pendulum case has moved through a distance equal to one half the wave-length of the light used, for a change of distance between the thinly silvered plate and the mirror on the pendulum case causes a change in the total path of the ray to and from that mirror by double that amount, so that if the length of the ray of light used is known we have a means of computing the movement of the case. The wave-length of sodium light is practically 0.58 microns, and therefore a shift or displacement of the fringe by an amount equal to one fringe-width means a displacement of the pendulum case of 0.29 microns. The correction to be applied to the period of the pendulum, when the receiver is mounted as in the Canadian work, is about 0ˢ.0000011, to be subtracted.

Below is an example of the computation of the observations made at Cochrane on July 21st, 1914:

	Bond.		Dent.	
		s		s
Period uncorrected		0.5012838		0.5012869
Correction for arc	—	12	—	12
Correction for temperature	—	91	—	91
Correction for pressure	+	11	+	11
Correction for rate	—	146	—	177
Correction for flexure	—	11	—	11
Corrected period		0.5012589		0.5012589

Deduction of the Absolute Gravity.—The ratio of the gravity at two places is given by the relation

$$P^2 : P_x^2 = g_x : g, \text{ or } g = (P_x/P)^2 g_x,$$

where P_x and g_x are period and gravity at the base station and P is the period at the field station. The observed value for Ottawa is 980.615 dynes, and the gravity at any station can readily be deduced when the period of the pendulum is known for Ottawa and for the field station.

During the summers of 1914 and 1915 pendulum observations were made at forty-two stations in Canada. These stations are scattered from Sydney in Nova Scotia to Vancouver in British Columbia; they cover about nine degrees of latitude. It is the intention in the near future to make observations at many more stations in our great Northwest, and also in other parts of Canada. The question may be asked: "What is the practical value of these observations?" That question probably can best be answered by quoting from a paper read by Mr. C. S. Peirce before a conference on gravity determinations held at Washington in May, 1882:

"(1) The first scientific object of a geodetic survey

is the determination of the earth's figure. It is probable that pendulum experiments afford the best method of determining the oblateness of the spheroid of the earth, for the calculated probable error in the determination of the quantity in question from pendulum observations does not exceed that of the best determination from triangulation and latitude observations. Besides, the measurement of astronomic arcs upon the surface of the earth covers only limited districts, and the oblateness deduced from them is necessarily affected. On the other hand, pendulum determinations are subject to no great errors which least squares cannot ascertain; they may be widely scattered over the earth, they may be numerous, they are combined to obtain the ellipticity by a simple arithmetical process; and the calculated probable error deduced from them is worthy of unusual confidence. It is very significant that while the value derived from pendulum work has remained very constant, that derived from measurements of arc has been continually changing as more data have been secured, and the change has always been in the direction to accord with the pendulum method. Also, the expense of the pendulum method is small compared with the geodetic method.

"(2) Investigation has shown the importance of pendulum experiments to metrology.

"(3) Geologists affirm that from the values of gravity at different points useful inference can be drawn in regard to the geological formation of the underlying strata.

"(4) Gravity is extensively employed as a unit in the measurement of forces. Thus, the pressure of the atmosphere is, in the barometer, balanced against the weight of a measured column of mercury; the mechanical equivalent of heat is measured in foot-pounds, etc. All such measurements refer to a standard which is different in different localities, and it is therefore very important to determine the amounts of these differences as the exactitude of measurement is improved.

"(5) It is hoped that as the knowledge of the constitution of the earth's crust becomes, by the aid of pendulum experiments, more perfected we shall be able to establish methods by which we can with confidence infer from the vertical attraction of mountains, etc., what their horizontal attraction, and the resulting direction of the plumb-line must be.

"(6) Although in laying out the plan of a geodetic survey the relative utility of the knowledge of different quantities ought to be taken into account, and such account must be favorable to pendulum work, yet it is true that nothing appertaining to such a survey ought to be neglected. The knowledge of the force of gravity is not a mere matter of utility alone, it is also one of the fundamental kinds of quantity which it is the duty of a geodetic or geophysical survey to measure. Astronomical longitudes and latitudes are determinations of the direction of gravity; pendulum experiments determine its amount. The force of gravity is related in the same way to longitude and latitude as the intensity of the magnetic force is related to the magnetic declination and inclination, and, as a magnetic survey would be held to be imperfect in which measurements of intensity were omitted, to the same extent must a geodetic survey be held to be imperfect in which the determinations of gravity have been omitted."

The value of gravity at a station depends upon the latitude of the station, upon the elevation above sea level, and upon the nature and density of the topography surrounding the station. Perhaps in a later paper these problems may be discussed, but in this article it is only the intention to outline briefly the methods of observing with the simple pendulum, and the value of the deduced result.

The Care of Ancient Monuments*

By C. H. Peers, Sec. S. A., Chief Inspector of Ancient Monuments and Historic Buildings to H. M. Office of Works and Public Buildings

The art of construction is a very ancient art, and many of the results of modern science have been anticipated by rule of thumb centuries ago, to be forgotten and rediscovered in different surroundings. A knowledge of such things is essential in dealing with ancient structures, where a mind in sympathy with the methods and ideals of the past is the only sure guide to a right treatment. It will be obvious at first sight that this will limit our choice of expedients; we must rule out treatments which are convenient and advantageous enough in new works, but incompatible with the old. But this does not mean that the results of modern science are inapplicable to ancient buildings, or that we should use no processes which were not known to their builders. Far from it; our claim to be a generation which values its inheritance of history must rest on our employment of all the means which are at our disposal for the preservation of that inheritance. But they must be used in the right way, and from this spring the limitations which must be observed. An ancient monument, speaking generally, has three precious qualities: Its history, its beauty, and its educational value; in attempting to prolong its existence we must not obscure or destroy these qualities. If something must be sacrificed to preserve the rest, the distinction between essentials and non-essentials must be clearly defined, or perhaps it would be more accurate to say that the relative importance of parts which are all by the nature of the case important must be apprehended. Dilapidation, when not due to intentional damage, may be said to arise from two main sources, damp and structural weakness; the accumulated shortcomings of nature and man.

We are accustomed to hear comparisons drawn between the work of former ages and our own, not to our own advantage. This is by no means always fair. There has been good and bad building in all ages, and in the course of nature more of the bad buildings have perished than of the good, and in consequence the achievement of any period which has left an appreciable number of works is liable to be judged on too favorable a ground. Even in such Roman buildings as are left there is no uniform standard of merit.

The Roman tradition of building with two faces and a core was continued in the middle ages, but often with none of the care and thoroughness which was necessary for its success. In the eleventh century, at any rate, the core in many instances was little more than earth and building rubbish packed in between wrought stone faces, these latter in small stones with shallow beds. Such walls would stand no great weight and were also particularly sensitive to any foundation movement or lateral stress, having no natural strength.

In a small building, where stresses are neither great nor complex, a weatherproof wall face protecting a weak core will often serve well enough for the time, but the ruin or reconstruction of many of our mediæval buildings has followed the adoption of such a principle. Walls were pointed in tolerable lime mortar, but built in nothing but clay, and as long as the pointing was able to keep the weather out, they were able to do the work for which they had been designed. But if, through any settlement or stress, a fracture developed, the masonry had no power of resistance, but fell away and became fit for nothing but pulling down, for lack of sound walling to which to bond a repair. It will easily be seen that it is almost impossible to strengthen such a wall so as to prolong its existence appreciably, without destroying its character, considering that its character is the very source of its weakness.

So much for the evil arising from the degradation of a tradition; but the dangers inherent in an imperfect scheme of construction, incidental to the growth of a style, are equally difficult to deal with. An overloaded arch or pier, an ill-calculated thrust, seem to demand for their complete cure so much substitution of new work for old, or such disfiguring ties and supports, that the balance of gain over loss to an ancient building draws perilously near to nothing.

A third evil, for which at present no adequate remedy has been found, is the decay of stone. This is a particularly important matter, as the loss of the surface of an ancient building, though not necessarily affecting its stability, is disastrous for its history and appearance. The causes of stone decay are various, but damp is an almost constant factor. By its agency acids which attack the structure of a stone are carried into its pores, and while a dry surface remains perfect, a ledge on which water can stand, a molding from which it can hang, or a face down which it commonly runs, will all begin to decay. The cementing material of the stone is attacked and its particles become loose and fall away; and the evil, once started, is progressive and not to be stopped, as has been often attempted, by the application of a weatherproof solution to the surface.

A series of experiments, having for their object the discovery of a really effective treatment, has been in progress for some time at Edinburgh, instituted by the Commissioners of Works; but though certain phenomena have been definitely established, it cannot be said that any general principle of treatment has yet been laid down. The difficulty lies not so much in getting a preservative solution to sink into the stone as in preventing it being drawn out to the surface again in the process of crystallization and evaporation.

In addition to the loss of a part of its fabric, there are minor losses, inevitable in the repair of any old building. Centuries of neglect have allowed the rain to soak into its walls and plants and bushes to grow upon them, thrusting their roots deep into the masonry and pushing the stones apart. The mortar has gradually yielded to damp and frost and crumbled to dust, or has fallen out, leaving the empty joints to act as channels for rain-water. All decayed mortar and earth must be raked out of the joints to a depth sometimes of a foot to 18 inches; the roots must be pulled out, the voids filled and the facing masonry pointed to keep the wall waterproof. Very little of the old pointing, if it survives at all, will be sound enough to do its work, and as a result nearly the whole of the joints in the walls will be new, and until their newness has worn off the general effect will be far less picturesque than before. The surface of the mortar joint is therefore of great importance, and it may be well to describe the practice of the department in raking out and repointing. All pointing, except on horizontal surfaces and wall tops, is in lime mortar, hydraulic limes being used, as for example, in England, blue lias lime from Leicester or elsewhere; in Scotland, Arden lime; in Wales, Aberthaw lime. The sand is to be as coarse and sharp as possible, and in order to bring it to the surface of the joint it is the practice to spray the joints with water before the mortar is set, in order to wash away the particles of lime and leave the coarse grit exposed. If the joint is more than three inches deep, it is backed with cement mortar up to three inches from the face to avoid the drawbacks of the very slow setting of a large body of lime mortar. Cement pointing is to be avoided because of its color and its hard and inelastic nature, and therefore greater tendency to crack away from the sides of the joint when set. On wall tops, however, and horizontal ledges it must generally be used, as lime mortar in such places is liable to get soaked with rain and in consequence to break up in frosty weather. If cement is used with a very coarse pebbly grit, breaking up its surface as much as possible, its ugly grey-white color is less noticeable.

*Abstract of a paper read before the Concrete Institute. Reported in *The Architect*.

Workshop Methods of Optical Testing

At the request of the Ministry of Munitions the Optical Society held an exhibition of workshop methods of optical testing at King's College, Strand, on January 11th, in order that by the interchange of workshop methods of test, the production of optical instruments for naval and military use might be expedited. Amongst others, Messrs. Chance Bros. exhibited a method for the rapid approximate assessment of strain existing in glass. A plate of mica is cemented between glass plates, the mica being of such thickness as to give a phase difference in the two beams of one wave for sodium light. This plate therefore gives approximately the sensitive first order color purple color between crossed Nicols. According to the orientation of the specimen double refraction will be evident from the change of the purple color to a tint of a lower or higher order. Each tint corresponds to a definite phase variation produced by the double refraction of the glass, and hence an estimation of the tints exhibited gives an estimation of the phase difference produced in a beam on passage through the glass. The colors given in conjunction with the wave plate are independent of the intensity of the light; thus greater uniformity in testing for bad annealing is obtained by the use of crossed Nicols alone, where the sensitiveness of the tests depends largely on the intensity of the source of light.

Messrs. Adam Hilger exhibited a new apparatus and process for finishing prisms and lenses which are imperfect in consequence of non-homogeneous material or inaccurate surfaces. The apparatus consists of a modification of the Michelson interferometer. A beam of light is passed through the optical element under test in such a way as to produce a series of interference fringes which constitute what may be called a contour map of imperfections. This map can be drawn on one of the surfaces of the prism or lens; superfluous material is then removed by local polishing until light is transmitted as in a perfect optical element.

Prof. Herbert Jackson exhibited samples of glass which had undergone a *weathering* test, by submission to the action of steam in an autoclave. The condition of glass surfaces after a standard test is an index of the behavior of the glass when subjected to normal atmospheric exposure.

The National Physical Laboratory exhibited the photometer used in testing the luminosity of radium-painted dials. The dial under test is placed between two "artificial dials" illuminated by an electric lamp placed behind a suitable green filter; the candle-power of the lamp is varied by means of a resistance. The instrument is standardized by the use of a surface brightness photometer for various currents through the lamp. Samples of glass were also exhibited made from sands obtained in England, to replace sands hitherto obtained from the Continent.—*Nature.*

The Metric System*

The Importance of a Universal Standard in International Commerce

The unexampled opportunity afforded by the great war in Europe for the advancement of the metric system, and its adoption and use in this country by bankers, merchants, and manufacturers engaging in foreign trade, has given such impetus to the metric system in domestic economic circles as to cause a new revival of the advocacy of the metric system as a practical business factor in this country.

The business community of the United States, as never before in its history, is reaching out in the world for trade. The opening of our new foreign-trade era will result in dismal failure or in pronounced success according to whether our financial and commercial adventurers do not or do proceed by competent methods in languages, customs, and weights and measures to do business. The last mentioned of these factors, as it concerns the unit or the individual in foreign lands, is the first in point of importance since the individual, the ultimate consumer, is the one to be catered to with a greater degree of attention than the importer or the banker or the distributor in these lands.

Weights and measures, whether concerning the metric system or other system used outside the United States, is a subject of primary importance in the relation between peoples; its knowledge in every-day affairs as necessary as is the knowledge of the language of the people of that foreign country.

The enterprise of countless American merchants and manufacturers, engaging in foreign trade heretofore never approached by them, satisfied with domestic concerns, should promote the study, adoption, and use of the metric system in their world trade. These fellow citizens, preparing to make new trade conquests, should make as part of their plan of campaign the introduction of the metric system of weights and measures. It is generally known that all countries outside of the United States, except Russia and Great Britain, use this system, and in these countries the use of this system is permissive. The system was legalized by the American Congress in 1866. It is permissive in character. Thus far, however, its operation as an element in domestic trade is practically unknown, its activity promoted only by diffident scholars whose ambition ceases with an exposition of its merits. There are only two nations in the world with whom we can trade on the basis of our own complicated system of weights and measurs, namely, Russia and Great Britain; and even here there is no general uniformity; for in the former country only one unit is similar, namely, the inch; and in the latter country the capacity measures are entirely different, thus making conversions necessary in these units. Are our new trade internationalists aware of that fact? The other countries in their use of the metric system promise us present and future trouble unless our people in dealing with them discard our system and adopt theirs. The United States and England have lost European and Latin-American trade because of this handicap. The world needs a universal language. That, however, will be longer in coming into realization than a universal metric system of weights and measures.

It may be many years delayed in being adopted generally for use in this country. Its adoption here, however, will be hastened by the new era of foreign-trade expansion, through which the American merchant and manufacturer will be obliged to adopt it in order to satisfy foreign-trade conditions. The demands made upon domestic firms for commodities made and to be distributed upon the metric-system basis will familiarize thousands heretofore ignorant of its usefulness with the system and its proverbial simplicity.

These demands, which must be met or prepared for before being made, will do more to educate our people in the uses and advantages of the system than a fortune spent in a literary propaganda. The American manufacturer in shipping and will continue to ship tons of raw material abroad, little realizing the immensity with which an item like the metric system of weights and measures counts with foreign trade. Added to the disadvantages of not making the terms of measurement understood to the foreign trader is the loss of profit in trade by reason of our goods not being in metric units, while various other items bring the total loss to material figures.

For simple convenience the metric system should be used by our people for both domestic and foreign trade. This system is as much superior to our system of weights and measures as the decimal system in money is superior to the English pounds, shillings, and pence.

*A report by Joseph Hartigan at the Eleventh Annual Conference on Weights and Measures held at the Bureau of Standards, Washington, D. C., May 23-26, 1916.

Considering the fact that there is not one American or Englishman in fifty who can give the values of half of our tables of weights and measures, it would seem an easy matter to make the change, but it is far otherwise. The fact that farms and town lots are laid off in acres, feet, or rods, that we are accustomed to the thought of the distance represented by a mile and the weight represented by a pound, makes it extremely difficult to inaugurate a change. To weights and measures officials, who are imbued with the metric system and advocate its adoption, its use is replete with meritorious advantages over our archaic system of weights and measures, but they consider it hopeless to attempt the accomplishment of a change. Tradition and custom and habit—brothers in misfortune—have dictated to our loss our system of weights and measures. It is difficult to explain how our wide-awake American populace for years has maintained two systems. Could not gold and diamonds be weighed with divisions of the same unit that measures flour? Why buy drugs by apothecaries' weight, rings by troy, and sugar by avoirdupois? Sometimes the architect makes his plan in tenths and hundredths of feet, and the carpenter follows to do the work with twelfths of feet and sixteenths of inches.

Our foreign-trade expansionists have not stopped to count the cost involved in expensive duplication of machinery for firms engaged in foreign trade. Our system creates confusion and waste every year. In comparison with a long list of resultant evils caused by our system can be set down the benefits to be derived under the metric system.

In the metric system there is but one standard of weight, but one standard of measure for liquid and dry commodities alike, and but one standard of length.

The metric system of weights and measures has so much in it to commend it that this report will be silent as to a summary of the benefits and equally free from from reference to the manifold complexities and wastefulness of our present system of weights and measures.

It is hard, as you know, for old dogs to learn new tricks, but it is easy for young dogs to learn new and better tricks than the older ones learned. The time taken in school with the subject of weights and measures would be materially shortened by use of the metric system, leaving children free to master some of the newer things considered necessary.

We all have been used to thinking in terms of the old standards for so long that the idea of changing to a simpler system strikes us in the lazy spots of our mentality, and we try to bolster up the old with all manner of scares about the new.

A striking illustration of the adoption and use of the metric system from a practical commercial standpoint is furnished by a bridge-building company in the Pittsburgh district several years ago which was running short of structural steel. Competition tried to hold them up on prices, so they ordered from Belgium. The orders for sizes and drilling had to be given in the metric system. The draftsmen thought at first they would have a hard time of it, but in three days they became so used to it they wished all their work might be in that system. The steel was used by the United States Government and it passed inspection.

At this particular time an agitation was started to have the United States Government require all its work to be done and its supplies to be furnished according to the metric system. It was thought by the advocates of the metric system that factories supplying the Government with material would comply in short order. The general opinion at that time was that some machines would have to be scrapped entirely, but most machines would require only changes in gears, and in gear cutting the metric system would be a distinct gain.

The American woman, however, quick to discern the new things affecting the economic situation, would perhaps be the most formidable objector to the adoption and use of the metric system. The particular reason underlying this attitude of mind is due, of course, primarily to the absence in our public educational system of more extensive methods of teaching and studying the various systems of weights and measures. It is surprising to know that in this modern day many of the lower-grade schools in this country have eliminated the tables of weights and measures from their curriculum. This must be attended to in time. The American women, however, do the bulk of the family buying, and these same American women have shown themselves equal to most, if not all, of the tasks set before them by the changes in modern life; and should the metric system, although not compulsory under the law of the land, in time become by common consent the weights and measures system of this country, they would soon be buying by the liter, the kilogram, and the meter as readily as they do now in the old system, and the family treasurer would pay the bill in decimal currency as he has to do to-day.

Since the metric system was legalized in the year 1866 in the United the agitation for its adoption and use has come primarily from men of science and students enthusiastically imbued with the simplicity of the system. Its application, however, to all the needs of the practical everyday life is absent.

While only permissive under the laws of this country, and while the United States Government itself has adopted and used the system only in certain of the governmental departments, its use has been made mandatory by law in the Philippines. Yet in the governmental statistical publications anything other than our own weights and measures system is very rarely used. In our tariff schedules specific duties are mostly fixed by our own weights and measures permissive under the Constitution of the United States, under which schedules, articles are to pay duties in terms of gallons, feet, yards, tons, etc.

The border line between foreign and domestic commerce is at the entrance port of the United States, and the crucial test of a system of weights and measures is its use in the tariff schedule. This is particularly true when nearly two-thirds of the world is using the metric system, and yet under the laws of the United States it appears that the American Congress prefers the old system of weights and measures to the metric system, both of which are permissive. It is obvious, therefore, that Congress has chosen our present system either because they are convinced of its greater practicability or else, in pure ignorance, they are not familiar intimately with the simplicity and advantages of the metric system.

Metric-system advocates favor a law requiring its adoption for governmental purposes, and also compelling its use generally, so ordering the law that the permissive or discretional feature be eliminated and the metric system solely substituted.

These advocates in this country in their ideal seek too much at the outset. Perhaps this is a cause for the delay in the adoption and use of the metric system here. While you may induce the Government to adopt and use it, commerce and industry will not use it and you can not force its use, until the people understand and are educated up to its beneficient advantages. But the mere introduction of a law compelling the adoption and use of the metric system will do some good. Its introduction alone attracts attention—especially the attention of the opponents of the system—and their opinions, loudly and forcefully expressed, are accepted by the people as the utterances of wise men, because the people are unacquainted with its meaning and construe the metric system as some horrible ogre that threatens disturbance, distress, and destruction. It is unfortunately true that metric-system advocates are regarded as typical reformers, and reformers in this country are looked upon askance. In these modern days let us not be known as reformers, promoters, or propagandists. Let us be projectors in the sense of advancing a project of mutual interest and advantage to all the people.

The metric advocate in his conflict with the uninformed is unwise when he ruthlessly combats their settled habits, their established usages, their domestic and individual economy, their ignorance, their prejudice, and their wants; all of which is unavoidably done in the attempt radically to change or originate a totally new system of weights and measures without first laying an adequate foundation for its reception.

In any plan which may be contemplated for the adoption and use of the metric system in the United States generally, it would be unwise to attempt to force this system through any legislative body unless a genuine public demand was first created. The adoption by law and the use of the metric system by the people should come naturally and without trouble, inconvenience, or coercive measures. The people of the various strata of society must first be educated by the introduction of the system in this branch of trade, that channel of commerce, through this gateway of industry, at the same time advancing the fundamental conception by building for future generations on a foundation to be laid through the public educational system in the schools, college, and universities of the United States.

The attitude of the American people must be so made up as to want this thing before it can be made a part of the general compulsory organic law of the United States. You must first create a demand from the people; other-

wise the American Congress will not listen. A bill will be accepted, referred to an appropriate committee, discussed and deliberated upon, hearings will be open to all concerned, with the ultimate result that the committee will declare that although the members are unanimously in favor of its legislation, it is wise not to report it to the main body, for two reasons: First, the Congress itself, able and intelligent in many matters, would not accept so radical a change by way of compulsory laws because there was no public demand; and, secondly, because the country, being unfamiliar with the metric system, would resent any action taken by the Congress to compel the use of that with which they were neither in accord nor understanding.

The metric system, then, if in time it is to be generally used in this country, must first be clearly understood before you attempt to compel by law the use of it. The system should be learned and made use of. You will grant that while this system has been before the country for years, it has a reputation generally for being a fad or a fancy. This impression must be removed. If, in the next generation, it can be taught to the children at the mother's knee a great advance has been made toward its adoption.

It is needless to go into the meritorious advantages of the metric system to a conference of weights and measures officials. Your experience teaches you how difficult it is to unravel present-day problems arising under our present system. You dream of and yearn for the simplicity of the metric system.

Into the work of scientific men the metric system was easily introduced. The scientific man, however, who advocates the adoption and use of the metric system must see beyond his own horizon in these matters. Those with him in advocating the metric system are liable to create for themselves a pitfall of error. Scientific men like other men, are subject to the limitations of human nature. Scientific men believe the change to the metric system for general use will be easy because in scientific work it was easy. The scientific use of measurement consists of measuring things. The industrial use of measurements consists in making things to certain sizes. It has been the rule that the advocates of the metric system are measurers of things, while those who generally come from the ranks of the opposition are makers of things. Now these things are at present made in our customary system unless the makers, because of commercial demands, are obliged to furnish the supply in the metric system. A change to the metric system, from the scientific man's standpoint, involves nothing but a change in measuring instruments, while the manufacturing interests of the country, the makers of things, are naturally affected to a greater degree, for they are compelled to pay the bills which come with the change. The scientist, the weights and measures official, and those engaged in a special study of the metric system, are familiar with its advantages and should now be generous and treat those liberally who are in ignorance. The primary object of the metric advocate should be to familiarize those with it who are without special interest therein.

A conspicuous example of the confusion arising from having more than one system is displayed in the building of the Panama Canal. This great twentieth century engineering feat was begun by the meter and completed by the yard.

Should the metric system come into general use in this country you must appreciate the salient and incontrovertible fact that the enthusiasm, sympathy, and intelligence which bring it about will cause new and grave problems to arise, which at that time must be treated with the same consideration as we give conditions which arise when night changes into day.

The modern advocate for the adoption and use of the metric system in the United States must have a plan—a constructive, definite, and detailed plan and program with accompanying directions. This plan should be so formulated as to arrange from time to time, year after year, for its introduction into new and virgin fields where it is now unknown or opposed. That which has already been accomplished through economic needs, foreign and export demands, through industrial efficiency and engineering interests; that which has already been accomplished in the halls of medicine and medical practice, and in the numerous arts, sciences, and industries wherein it is now a fact, stands out to the credit of the advantages of the metric system and can be pointed to as an example for its adoption and use elsewhere. The plan should follow the permissive law of 1866, taking up the subjects and conditions which it may control, not generally, but phase by phase, situation by situation, condition by condition, trade by trade, and so on ad infinitum until the top is reached, even if it takes a generation or two to reach the goal.

It would be absurd to hope to accomplish the apparently impossible unless the field to which you expect to apply the metric system is surveyed, nurtured, and harvested through the medium of a distinct and separate plan for each particular purpose.

The project, when introduced in practical modern-day fashion, beginning at the bottom rung of the ladder, not at the top, will render to the projectors a return commensurate to the effect they put forth.

Since he may provide himself with the tools which are so ready to his hand, namely, the ancient and modern example, the history, political, financial, and economic of the world through which, strange to say, the metric system has wormed its way with curious results, good and bad, and the literature printed in all the modern languages pro and con, the missionary who goes out is well equipped for the project.

Under a plan of action well prepared and practical to bring about the adoption and use of the metric system in the United States you will have, for the first time in the history of the metric system, and more especially in this country, attempted the projection of a revolutionary change with all the prospects of success. Never before in the economic history of this country has such a plan been proposed or attempted.

A committee on the metric system, national in character, should be retained by the National Conference on the Weights and Measures of the United States from year to year. Its report might be based upon what it has been able to accomplish during the year preceding with reference to the progress made in the adoption and use of the system in the various factors of trade, commerce, industry, public education, and legislation, and the committee should be authorized to make such recommendations as are deemed necessary for the continued forwarding of the project with the coöperation of its advocates.

The plan as outlined should be definite and exact, subject, however, to changes which may be necessary which can not now be foreseen. The plan should comprise, for example, during the year 1916–17 an introduction of the metric system to commercial and industrial firms who, although not now affected by foreign-trade expansion, are within the same circle of influence as many firms who have been affected and who have adopted and are now using the metric system. So on to the end of the line, year after year, the project to be carried into the shop of the worker, instead of requiring or waiting for the worker, the pupil, to come to the teacher.

The project can not in the wildest dream of its most enthusiastic supporter expect immediate adoption and use. The road is long and difficult of travel and many and serious obstacles beset the program. While the metric system has millions of advocates in the world, our purpose is gradually to enlist the support of millions who will then commence to use it in the United States, with the ultimate aim of the destruction of the many horned species of weight-and-measure-system animals now roaming through the Nation.

We can only attain our aim by patient and persistent effort on a definite plan applied to the elements now ignorant of the metric system or opposed to it. The conditions before us may not hold promise in this generation of its universal adoption, and use in the United States. The attempt to bring it about, however, in this generation through systematic effort may be rewarded by surprising results. If in this generation we are unsuccessful and have ended our labors here at the call which comes from on high, our successors may continue the spread of the gospel of weight and measure simplicity represented by the metric system with more assurances of a successful outcome in view of the coming of an expected superior intelligence with future generations, who will accept the metric system as truth and tradition, as a force to cement world relations, hand in hand with a universal language.

The metric system of weights and measures fits into the general scheme for international friendly intercourse. To that end all just men are striving. When the millennium comes the energizing forces of men will have accomplished much under the definite guidance of Almighty God if they have agreed upon a universal language and the universal use of the metric system of weights and measures.

Quantitative Microscopy

A METHOD described for the quantitative microscopical examination of mixed powders depends on the addition of a substance consisting of uniform grains and then determining the ratio of the constituents to the added grains. The details of the method are as follows:—A mixture of equal weights of the pure substance under examination and of the adulterant is prepared; 0.2 grm. of this mixture is mixed with 0.1 grm., or other suitable quantity, of lycopodium and sufficient of a suspending fluid (this may be an oil, soft paraffin, glycerol, or other suitable liquid) to produce a liquid of which 1 drop, when mounted and examined with a $\frac{1}{6}$ inch objective, will show from 10 to 20 lycopodium spores in each field. In most cases this will be attained when the volume is about 20 c.c. A drop of the suspension is transferred to a slide, a cover glass is applied, and the numbers of particles of adulterant and of lycopodium spores are counted in ten different fields. Another drop is then mounted, and counts are made. The ratio of the number of lycopodium spores to the number of characteristic elements of the adulterant is expressed as a percentage of the lycopodium spores; the results of the two counts should not differ by more than 10 per cent. A quantity of 0.2 grm. of the actual sample is then mixed with 0.1 grm., or other suitable quantity, of lycopodium and about 20 c.c. of the suspending fluid, drops are mounted on each of two slides, and counts made. The results of the counts are expressed in the same way as in the case of the standard mixture. The numbers obtained for the foreign ingredient are directly proportional to the amounts present and a simple calculation gives the quantity. Unless the powders have been dried previously, a correction must be applied for moisture. The method is applicable to a large variety of mixtures, including starches, food products, and drugs, of which examples are given. Even in the case of a mixture of two starches the addition of lycopodium is an advantage, since greater precision is secured.—*T. E. Wallace in the Analyst. From a note in the Journal of Society of Chemical Industry.*

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Table of Contents

PAGE
What Is a Disease?—II.—By Charles Mercier 162
How Eclipses Occur.—By Frederick R. Honey.—5 illustrations 164
Directing an Attack 165
Potatoes as a Food 166
New Evidence in Regard to the Instability of the Human Types.—By Franz Boas 167
Stone and Concrete Road Foundations.—By Geo. C. Warren.—6 illustrations 168
Sound Areas of Great Explosions 169
Man and the Universe.—By C. M. Kilby 170
Developing and Toning of Motion Picture Films.—By Charles I. Reid 171
Gravity.—By F. A. McDiarmid.—2 illustrations 173
The Care of Ancient Monuments.—By C. H. Peers 174
The Metric System 175

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ach field.
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N. Y.

PAGE
163

164
165
166

167

168
169
170

171
172
174
175